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RECENT DEVELOPMENTS IN MOTOR COACHES UPON BRITISH RAILROADS.

By the English Correspondent of SCIENTIFIC AMERICAN.

THE utilization of motor coaches upon British railroads, over those sections of track which extend through sparsely-populated districts, is rapidly extending. To-day there are over one hundred of these types of vehicle plying upon the various systems, and the practice is being continually developed. By this means the traffic, both passenger and freight, which was not remunerative under the former régime, where a train comprising a small locomotive with two or three coaches was employed, has been turned from a dead loss to a profit. Owing to the rapidity with which this class of traffic is developing, several improvements in the types of vehicles are being adopted.

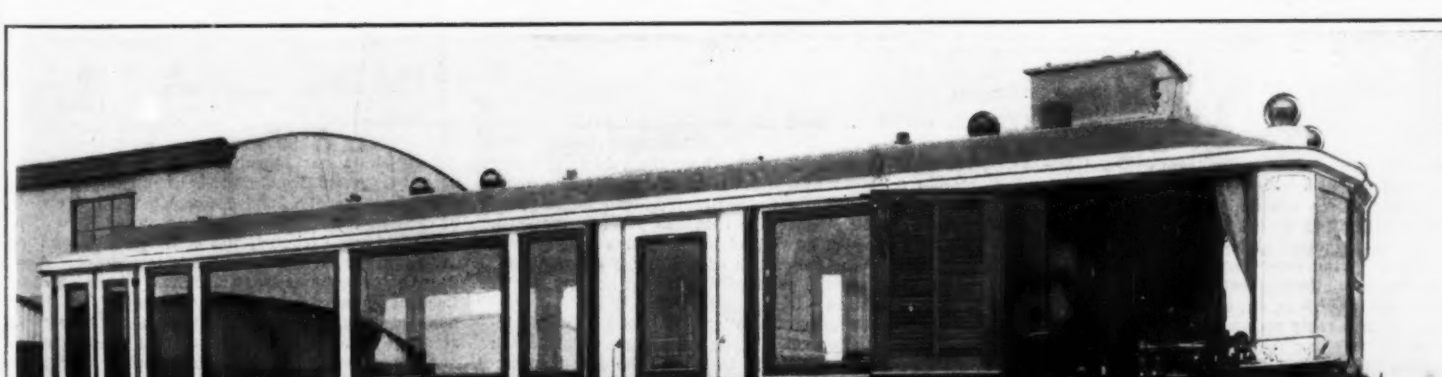
One of the most interesting of these developments is the Peebles steam car, the experiments with which have occasioned considerable interest among British railroad engineers. The system adopted has been evolved by the Peebles Steam Car Company, Ltd., of London, in conjunction with Messrs. Ganz & Co., of Budapest. The vehicle contains several noticeable features, the most important of which is that a light high-speed engine, in lieu of the general heavy locomotive type, is adopted, and it has proved far more suitable and satisfactory for this class of work, while gearing similar to that in vogue upon electric cars, for the transmission of the power from the motor to the wheels, constitutes another novelty in this class of vehicle.

In this coach the motive power equipment comprises a light high-duty water-tube boiler of special construction, supplying steam to a compound engine geared to the car axle and working at a fairly high speed, on superheated high-pressure steam. The boiler is placed in the center of the driver's compartment, which is placed at the end of the car. It is of special design, and contains many interesting features. Four steel cylinders, arranged concentrically, form the essential parts. The annular spaces between the two outer cylinders and the two inner cylinders are connected by a very large number of small tubes aggregating seven or eight hundred, which constitute the major portion of the heating surface. The hot gases, as they leave the fire, pass through the annular space between the innermost cylinders and play upon the tubes, so that a perfect degree of combustion is insured. As the water level is below the top tubes, these have the effect of drying and superheating the steam. As the total quantity of water in the boiler is small, a continuous feed is maintained by means of pumps, the capacity of which is regulated to correspond with the quantity of steam consumed. The boiler is designed to work at a pressure of 200 to 300 pounds per square inch, which pressure can be raised within a period ranging from twenty to thirty minutes with good fuel such as either coke or steam coal.

THE COACH, SHOWING BOILER AND ENGINE IN POSITION. WITH THIS ENGINE-COACH A SPEED OF 60 MILES AN HOUR WAS OBTAINED.

The four cylinders which constitute the boiler shell are embedded at their ends in heavy ring castings, which are stayed by through vertical bolts, as may be seen in the illustration. The joints are packed with copper wire, and the boiler is replete with all safety valves, etc.

The fuel is introduced through the funnel formed by the inner walls of the boiler. Under the boiler the ashpan is placed. This can be quickly emptied by tilting through the depression of a foot-lever, while there is also a door for the regulation of draft and to facilitate the cleaning of the boiler. A valuable feature is the provision made for the instant and easy removal of the boiler if necessary for any purpose, such as overhauling or repair, and the substitution of a spare one while the repairs are being effected. By this means



THE GEAR-DRIVEN STEAM MOTOR COACH.

RECENT DEVELOPMENTS IN MOTOR COACHES UPON BRITISH RAILROADS.

the car need not be put out of service through failure of the boiler, since it is only necessary to hold a boiler in reserve. The dimensions of the boiler are reduced to the practicable minimum, that for supplying a 35-horse-power motor being 3 feet 9 inches in height by 2 feet 8 inches in diameter.

A departure from the usual practice is adopted in connection with the motor, which is separated from the body, and is suspended from the under frame of the car, as is the method with an electric motor. Thus by releasing a few bolts the motor, together with its attendant gearing, can be removed for inspection without in any way interfering with the motor truck and wheels. The engine is of the cross-compound type with steam-jacketed cylinders. The 35-horse-power engine has cylinders of 4.7 inches and 6.7 inches bore with a stroke of 5½ inches, working normally at 600 revolutions per minute, at which speed the above horse-power is developed. For larger and heavier cars a 50-horse-power motor is employed. The slide-valve gear is of the simplest type suitable to high-speed running. A by-pass is fitted, so that at starting boiler steam can be admitted to both cylinders, thus supplying the large tractive effort necessary for starting and accelerating without necessarily increasing the size and weight of the engine.

Between the crank shaft and the driving axle is introduced an intermediate shaft carrying three gear wheels. One of these wheels is in permanent engagement with a gear wheel on the axle. The two remaining gear wheels on the intermediate shaft are of different diameters, and engage with two pinions on the crank shaft, which are loose on the shaft, and can only be brought into operation one at a time by moving a clutch. With one combination half speed is obtained, and by the engagement of the second gearing full speed is attained. The half-speed gear is used for starting and for the negotiation of heavy gradients if necessary. By using this gearing and opening the by-pass to the low-pressure cylinder, a tractive effort greatly in excess of what otherwise would be possible is obtained as occasion demands. The use of gearing is somewhat of a novelty upon steam railroad coaches, but its employment enables a lighter type of motor to be employed to produce the necessary tractive effort both at starting and when running up-hill. Furthermore, driving through gearing supplies the additional advantage of giving more uniform impulses upon the driving wheels, while the coefficient of adhesion is accordingly increased. Again, swinging or oscillation of the car is considerably reduced.

The motor is slung from the framework by spring suspension, with flexible connection with the boiler and universal couplings to the operating rods for moving the clutch, etc. All the working parts are inclosed in water and dust-proof casing and run in an oil bath. Wear and tear of the moving parts is thereby reduced to the minimum. The motor is economical with lubricant, from 10 to 12 pounds of oil per month only being used. The cylinders are provided with forced lubrication, about one ounce of oil being sufficient for a ten-mile run. The exhaust from the engine is fitted with a water separator. There are two feed-water tanks for supplying the boiler, one on either side. They each have capacity for 250 gallons. The feed pumps are in duplicate, and are of the direct-acting type automatically regulated.

The control of the vehicle comprises three levers—one for governing and reversing the steam motor; another for controlling the by-pass valve, allowing the engine to be run either as a twin cylinder or compound engine; while the third lever actuates the clutch on the crank shaft, which brings the gearing into action. All three levers are placed beside the boiler, within convenient reach, so that the driver can manipulate them without taking his eyes off the track. The car can be run from either end. In the case of the heavier vehicles, where two sets of motors are provided, the two boilers are placed at one end to facilitate stoking and handling. Ample braking facilities are provided, there being powerful hand brakes acting on all wheels, and air or vacuum brakes. With this car speeds varying from 30 to 60 miles per hour can be obtained. The introduction of the gearing enables a high degree of acceleration to be obtained without any undue stress on the working parts.

These coaches have been in operation upon several European railroads, and have proved highly economical and efficient, both in operation and maintenance. With the 35-horse-power motor coach the fuel consumption averages 6.5 pounds, and a water consumption of 4.5 gallons per mile. The total running cost averages 6 cents per mile, including fuel, oil, attendance, etc. On the state railroads of Wurtemburg this type of coach has been running in opposition with Daimler gasoline motor coaches, Serpollet steam cars, and electric accumulator-driven coaches. The results of the four systems are as follows:

	Daimler Gasoline Motor.	Serpollet Steam Motor.	Accumulator.	Peebles Steam Motor.
Weight, tons	11.28	20.14	32.22	13
Seating accommodation	24	82	56	33
Mileage per day	59	56	56	124
Fuel and water costs (cts. per mile)	1.4	1.18	....	1.04
Oil costs (cts. per mile)	0.096	0.091	....	0.04
Total costs (cts. per mile)	1.496	1.271	4.0	1.08
Maintenance costs (cts. per mile)	0.062	0.039	0.072	0.033

From the above it will be seen that the advantage is greatly in favor of the Peebles steam car. Similar results have also been obtained upon the Hungarian state railroads, in Bavaria, and on other European systems. In Great Britain, where the vehicle is being closely followed by railroad engineers, it has proved highly successful, being realized as the nearest approach to the electric car that has yet been devised, and is consequently well adapted for those sections of track where the exigencies of traffic are not sufficient to justify the huge expense that would be entailed by an electrification scheme.

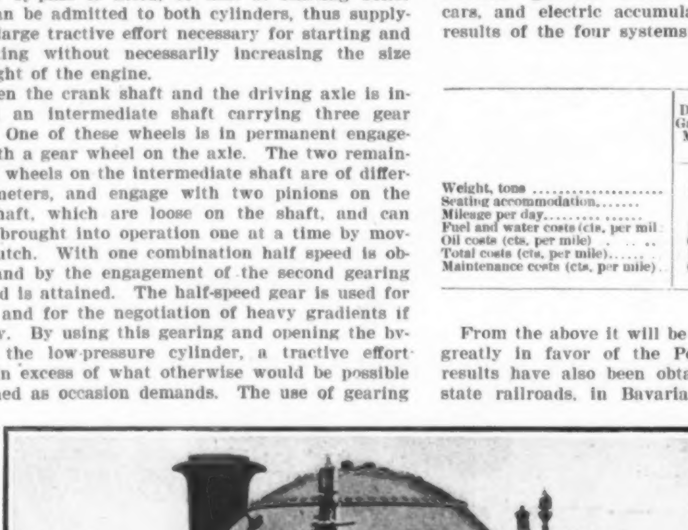
The Great North of Scotland Railroad has also introduced a motor coach upon its system. This coach has several interesting features, the most prominent of which is the engine. The coach has been designed by Mr. William Pickersgill, the railroad locomotive superintendent. The boiler is an adaptation of the well-known Cochran boiler, specially modified for locomotive work, and is the first application to this kind of work. The accompanying illustration of the boiler, which was built by Andrew Barclay & Co., comprehensively shows its design. The shell of the boiler is 9 feet 6 inches in height over all by 6 feet in diameter. The boiler is fitted with 295 horizontal return-fire tubes of 1½ inch outside diameter by 3 feet 11½ inches long. There is a grate area of 9 square feet, and a heating surface of 500 square feet.

The furnace is of hemispherical shape and is pressed hydraulically from a single flat plate, so that there are no seams or rivets exposed to the action of the fire. The two openings for firing and out-take respectively are also made without riveted flanges, and the foundation ring is also fashioned from a single plate. This system of construction avoids any local heating attributable to thick joints, while the tendency to grooving at the edges of such joints is also overcome.

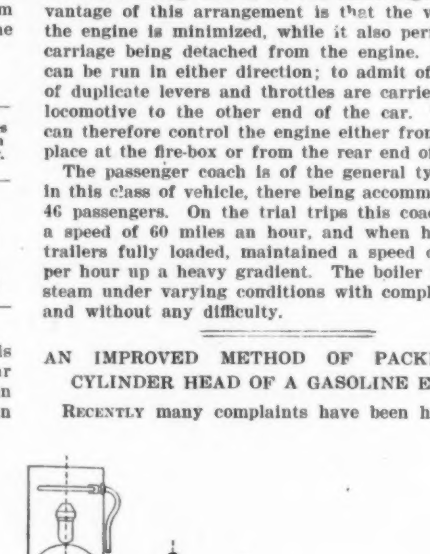
The boiler is fired from the footplate in the usual manner, but the waste gases, etc., leave the firebox at the side, and by a fire-brick arch are deflected so as to pass through the lower half of the tubes set transversely, that is at right angles to the usual position in locomotive boilers. The gases then meet in a combustion chamber, whence they pass through another series of tubes similar to the foregoing, above the firebrick arch, finally escaping through the chimney. There is a door on each side, through which access can be had to the ends of the tubes.

The engine is fitted with a valve gear of the Walschaert's type, and the valves work in slanting faces above the cylinders. The cylinders are 10 inches diameter by 16 inches stroke, and the boiler pressure is 150 pounds. The water tank is situated under the carriage. The car frame passes under the footplate, and carries a pivot piece which sits in a movable bolster working between sliding faces and resting on springs, the whole being carried on two knife edges. The advantage of this arrangement is that the vibration of the engine is minimized, while it also permits of the carriage being detached from the engine. The coach can be run in either direction; to admit of this, a set of duplicate levers and throttles are carried from the locomotive to the other end of the car. The driver can therefore control the engine either from his usual place at the fire-box or from the rear end of the car.

The passenger coach is of the general type adopted in this class of vehicle, there being accommodation for 46 passengers. On the trial trips this coach attained a speed of 60 miles an hour, and when hauling two trailers fully loaded, maintained a speed of 30 miles per hour up a heavy gradient. The boiler maintained steam under varying conditions with complete success and without any difficulty.



THE COCHRAN BOILER FOR THE PASSENGER COACH OF THE GREAT NORTH OF SCOTLAND RAILROAD.



SECTION OF WATER-TUBE BOILER OF PEEBLES GEAR-DRIVEN STEAM COACH.

RECENT DEVELOPMENTS IN MOTOR COACHES UPON BRITISH RAILROADS.

AN IMPROVED METHOD OF PACKING THE CYLINDER HEAD OF A GASOLINE ENGINE.

Recently many complaints have been heard about difficulties in packing the cylinder heads of engines used in several well-known automobiles. Such complaints are hardly just. Failure through blowing out of cylinder head gaskets need not occur if the job has been properly executed, and criticism of constructions necessitating such packing tends to prejudice the prospective purchaser against machines otherwise of merit. Lack of knowledge of what happens "out on the road" has led many thoroughly practical constructors, designers, and shopmen into making mistakes, which are recognized as such only by the users and operators. Since such is the case it behooves the shopman to come forward with a little advice to the just as well-meaning, but not quite as mechanically trained man "behind the wheel," pointing to a method of putting in gaskets which has proven very efficient, and which has been practised in many shops throughout the country.

The sheet packing commonly known as "Kearsarge" brand, an asbestos-rubber composition with an intermediate layer of wire netting, already incorporated into the packing, has been the most satisfying medium for securing permanent cylinder head packing. Single thickness is preferable to double.

The order of operations in packing a cylinder head would be about as follows (the gasket is supposed to be in readiness): Scrape flat packing surfaces on the cylinder head, as well as on the cylinder end, with a putty knife or similar piece of flat steel until all particles of the old packing, soot, and dirt have been removed. It is very essential to remove all traces of oil. If gasoline is employed for this purpose, care

should be taken to do this so thoroughly that no thin film of diluted oil remains spread over the packing surfaces. As a safeguard it is advisable to follow up the gasoline wash with one of wood alcohol.

Coat the flat packing surfaces on cylinder end and head with a layer of yellow shellac dissolved in alcohol, using a paint brush for this purpose. When it does not "stick" to the touch of the hand any more, put on a second coat of shellac. Wash the gasket well with wood alcohol, removing all trace of soapstone and grease. Between the first and second coat to the cylinder surfaces the gasket has applied one painting with the same shellac solution. After the second coat to the engine parts the second coating is applied to the gasket also.

If openings are to be cut into the gasket for water circulation or for ports, especial care must be taken to cut these openings in the gasket about three-thirty-seconds of an inch larger all round, because the packing, upon being compressed by the studs, will become larger, "grow," as it were, and protrude with its edges into the apertures referred to, and if some of these communicate with the combustion space, self-ignition will often occur after a short time, owing to ragged portions of the packing becoming incandescent, and remaining so for a long time.

The gasket may now be placed over the studs upon the cylinder end, and the head over the studs upon the gasket. Screw up all nuts evenly in rotation, little by little, giving each one a few turns until it "draws," going to the next one, and keeping this process up until all nuts are known to be equally and sufficiently tight to permit of starting engine. Of very many jobs which cannot be hurried and give good results, the screwing down of a packed head is one. The packing material needs time to be compressed and accommodate itself to the new conditions. If the drawing up of nuts is done slowly, it is surprising to note how often one can return to a nut, and take up just about a quarter turn after it was believed to be "home" as far as it would go.

The engine may now be started. When the cylinder and head are well warmed up, after running for about half an hour, go around the entire set of studs and again draw up the nuts. Nearly in every instance the total amount of taking up which can now be done will be found to aggregate almost one entire turn of each nut. Do this gradually, as described above. After several hours' running it is advisable to go around the nuts again, repeating this operation during the next few days after putting in a new packing. A cylinder head packed in the manner described will remain "tight" for many months. The process described may not be a very rapid one, but it is certain to give good results and obviate repacking for a long time. It will lessen complaints about heads which do not "stay" packed.—English Mechanic and World of Science.

THE TOLLI SPRING GOVERNOR.

By EMILE GUARINI.

THE Tolli governors, which are now extensively employed in Germany, and are manufactured by the Wiede Société Anonyme et Fabrique de Machines, of Chemnitz, Saxony, have the peculiarity that any thrust on the sleeve designed to change the number of revolutions within any limits whatever exerts no influence upon the nature of the governor. The regularity of the latter remains the same for the new number of revolutions, for which it is set, and unstable intermediate states do not occur.

The construction of the Tolli governor can be readily seen in the illustration. The centrifugal force produced by the revolution of the disks around the shaft of the governor is kept in equilibrium in a very simple manner by the tension of spiral springs placed at right angles with the shaft. The effect of the centrifugal force is nearly directly contrary to that of the power of the spring, a fact which assures almost completely the bolts against breaking. The degree of sensitiveness of the governor is therefore very great.

The use of a spiral traction spring assures the establishment of the necessary ratio between the variation of the length of the springs and their tension.

Two vertical springs mounted on two rods support the sleeve. When this spring is stretched, the number of the revolutions and the energy of the governor increase without any change in the degree of irregularity being produced. If, on the contrary, the horizontal springs be stretched, the degree of irregularity will be very perceptibly diminished, and *vice versa*. A change in the tension of the horizontal springs with a view to changing the degree of irregularity will also result in a change of the number of revolutions. In order to re-establish the previous number of revolutions, the tension of the vertical spring must likewise be changed in a corresponding manner. It is not necessary to change the tension of the horizontal springs in order to change the number of revolutions.

The Tolli spring governor therefore affords the possibility of changing the degree of irregularity in order to render it conformable to the permanent properties of the motor, and also the possibility of changing the number of revolutions in order to finally fix it exactly.

The following is a table of the operation of the Tolli governors:

Number of the Governor.	0	1	2	3	4	5	6	7	8	9	10	11	12
Revolutions per minute	360	340	320	300	300	300	300	290	280	260	250	230	220
Mean force of divergence per 2% change of velocity	1.26	2.14	3.2	4.48	5.2	6	7	8.48	10	12	16	23	30
Mean power	31.5	53.6	80	112	130	151	175	212	252	296	394	576	750
Rise of one sleeve, millimeters	28	33	38	44	48	51	55	60	66	72	80	100	110

There is a special form of these governors adapted for use with steam engines, for driving pumps. These are constructed particularly for considerable changes in the number of revolutions, and with them it is possible to obtain, during the running of the engine, changes up to more than 100 per cent; and from this point of view there is no limit except in the height permitted by the construction of the lateral vertical springs. This type of governor may be advantageously employed for engines, pumps, compressors, etc., since with any number of revolutions whatever, such an apparatus permits of utilizing the complete rise of the sleeve, and thus, even with a very variable pressure of steam, always operates equally well. In cases of this kind, the apparatus called efficiency governors do not usually permit of sufficient regulation, and therefore have not met with much success. It is conceded that governors of this type should control the same quantity of steam, that is to say, the quantity necessary corresponding to the steam diagram, which is supposed also to remain constant. This can occur only when in the engines under consideration, including those for pumps, compressors, etc., the resistance and the pressure remain always the same. If a change of load or of a pressure of the steam occurs, the governor, conformably to the different resistance, will control another quantity of steam, and, owing to the new height of the sleeve will make a different number of revolutions, limited by the strongly static character of the governor. In all similar cases, we shall always have a poor regulation, and the number of revolutions

THE TOLLI SPRING GOVERNOR.

of the engine will change within quite wide limits. So, it is evidently better to submit this kind of apparatus to a regulation of precision, and to control the work, that is to say, the number of revolutions, by means of movable weights adapted to the governor, or also control it, as in the case of the Tolli governors, by means of springs which stretch more or less and at the same time preserve a determinate degree of irregularity. Besides, with variations of pressure of the strongest character and the most considerable variations of load, we shall always obtain an exact regulation without any great variation in the number of revolutions.

The following is a table of the operation of the Tolli spring governor for changing the number of revolutions up to + 100 per cent:

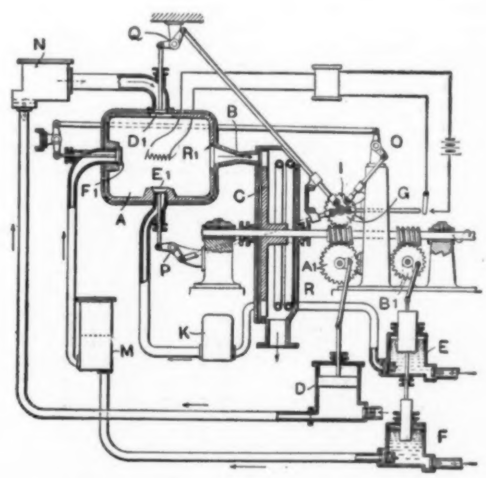
Number of the Governor.	1	2	3	4	5	6
Normal number of revolutions a minute, norm. *t*	200	195	190	185	180	160
Maximum number of revolutions a minute, norm. *t*.	400	390	380	370	360	320
Mean force of divergence per 2%, norm. *t*.	3.2	4.8	6.8	9.2	12.24	15.4
Change of speed, max. *t*.	12.4	19.2	27.2	36.8	49	61.6
Normal power, norm. *t*.	80	120	170	230	304	385
Maximum power, norm. *t*.	320	480	680	920	1224	1540
Rise of the sleeve, mm.	40	50	60	70	80	90

Upon the whole, the advantages of the Tolli governor may be stated as follows: Great sensitiveness, which, as well as the power, is nearly constant for all positions of the sleeve; possibility of obtaining any desired degree of regularity; change of the number of revolutions and of the power during the running of the motor, within wide limits, without alteration of the degree of regularity; extreme ease of regulation by equal force of transformation; degree of irregularity completely independent of the load of the sleeve of the governor.

ZOELLY EXPLOSION GAS TURBINE.

IN explosion gas turbines hitherto used, a suitable gas mixture is exploded in a closed chamber, i. e., at a constant volume, and, after the highest pressure has been reached, is conveyed to the turbine. The gases are then allowed to expand until their pressure sinks to that in the turbine casing, whereupon the chamber is closed and a new charge introduced. The chief fault of this system is that the pressure of the driving medium during the time that it is being supplied to the turbine, running at a constant speed, varies to a very considerable extent, so that toward the end of the expansion period the energy of the gas mixture is not properly utilized—at the nozzles on account of insufficient head, and at the turbine wheel on account of insufficient velocity of the gas, the result being loss of efficiency.

Heinrich Zoelly, of 58 Rämistrasse, Zurich, proposes in a recent patent to overcome these drawbacks in the following manner: Combustible gases, compressed to a given pressure, and with the air necessary for combustion, are admitted into the explosion chamber at the exact moment when the pressure of the gases from the previous explosion has sunk to a value equal to that of the new charge, so that such gases are expelled from the chamber with a constant pressure. In order to prevent premature ignition, the



ZOELLY EXPLOSION GAS TURBINE.

air valve is opened earlier than that controlling the gas, so that an isolating cushion is formed between the new and the old charge. When the chamber is nearly filled with fresh mixture, the inlet valve is closed, and the charge ignited, without, however, the outlet to the turbine being closed. Owing to the explosion only lasting an exceedingly short time, it may be assumed that the volume of the gases during the explosion remains constant.

After the maximum pressure has been reached, steam generated by the waste heat from the turbine itself is introduced into the explosion chamber at a pressure equal to that of the explosion, this constituting a "full-pressure period" as in a steam engine, and the temperature of the gases is reduced to such an extent that subsequent expansion in the nozzle results in temperatures which are not likely to be injurious to the buckets or vanes. After a portion of the gases has escaped during the full-pressure period, expansion begins, but is allowed to continue only down to the pressure in the (charge) compressor, the inlets opening again as soon as this latter pressure is reached and admitting a fresh charge at the compressor pressure, whereupon the process described is again repeated.

The characteristic features of the new process are (1) the explosion takes place with the inlet to the turbine open; (2) the stopping of the expansion at the compressor pressure; and (3) the introduction of steam at the explosion pressure, so that during a given time-period the mixture must escape at the full pressure.

The accompanying diagrammatic sketch shows the arrangement of the turbine. *A* is the combustion chamber, *B* the expansion nozzle, and *C* the turbine wheel. Air, water, and fuel are compressed by pumps *D E F* and conveyed to the combustion chamber through conduits and air vessels *N M K*. From the pump *E* water first passes into a regenerator *R* heated by the exhaust gases, where it is completely evaporated.

The valves D_1 E_1 F_1 admit at suitable moments the various media, and are operated by a suitable valve gear. The latter is diagrammatically indicated by worm wheels *G A*, B_1, cam *I*, and levers *Q P O*. The ignition device is indicated at R_1.

AN AMERICAN PHONETIC LABORATORY IN GERMANY.*

By HUGO FREIHN. VOM HAGEN, Major a.D.

EXPERIMENTAL phonetics as a science is a gradual development from the other sciences. The impulse for investigations of this character was primarily given by the works of Helmholtz upon the nature of the vowels. In more recent times the physiologist, Prof. Hermann (Königsberg) has achieved marked successes

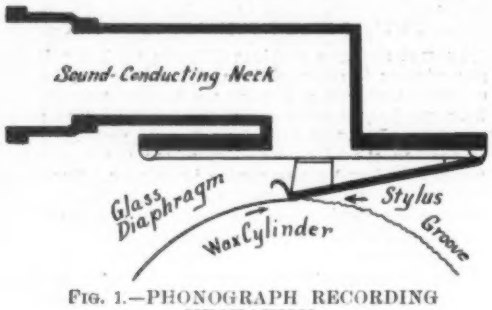


FIG. 1.—PHONOGRAPH RECORDING MECHANISM.

in transcribing phonograph curves and calculating them. Several years ago the College de France founded in Paris a small laboratory for experimental phonetics under the direction of the philologist, Abbé Rousselot. There, too, the investigations upon the organs of speech have been attended with considerable success.

Prof. E. W. Scripture, of Baltimore, works from an entirely different standpoint. As a pupil of Prof. Wundt, of Leipzig, who is known not only as the foremost investigator in the field of experimental physiology, but also as the author of an excellent work upon the physiology of speech, it occurred to Prof. Scripture to apply the general methods of the exact sciences—experiment and measurement—to the problems presented by the poetic art or art of versification. A truly scientific investigation must not, however, be limited merely to the printed letters of a composition, but must also investigate the spoken words from the mouth of the author, as well as the poetic feelings of the people. In connection with the physiological laboratory of Yale University, Prof. Scripture, its direc-

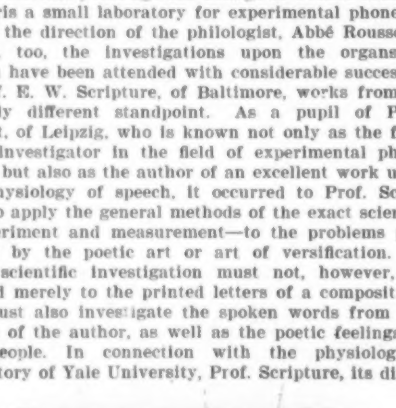


FIG. 2.—PHOTOGRAPHIC ENLARGEMENT OF A SECTION OF PHONOGRAPH CYLINDER SURFACE.

tor, had established a phonetic department as early as 1896. The work undertaken in this direction attracted the attention of the Carnegie Institution, and through this Prof. Scripture was enabled to continue his investigations on a larger scale by release from his educational duties, and by pecuniary assistance. As the scientific conditions in Germany appeared to be most advantageous for his purpose, he undertook his investigations first in Munich, and later in Berlin. As director of his private laboratory at the latter place, I have been permitted to recount the arrangements in this establishment, the methods, and the highly interesting work conducted there. (The final results will first appear in a series of contributions to the Carnegie Institution.)

In Munich the well-known physiologist Prof. Lipps assisted at a portion of the work by the loan of apparatus. In Berlin the gramophone transcribing apparatus, spoken of below, was erected in the Physiologist Institute (Prof. Stumpf) and used for investigation by the English School. In establishing the laboratory it was first necessary to find a suitable, that is educated, staff to carry out the measurements and curve calculations. In Munich the assistants included doctors of philosophy, retired army officers, university, college, and polytechnic students of the upper classes, at times as many as twenty-five individuals all working at once. In Berlin chief consideration was given to the working out of the results. The most important labors consisted of the recording of speech by

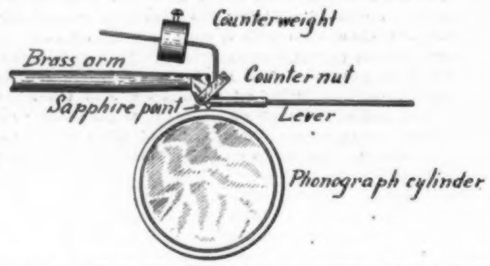


FIG. 4.—SIDE ELEVATION OF THE ROTATING MECHANISM.

means of the phonograph and gramophone, and of the study of the curves obtained in this manner.

The reader must clearly understand that the records of sound for reproductions are made by two principal methods.

1. In the case of a phonograph record the sounds are directed into a funnel, so that the sound waves cause a glass diaphragm to oscillate or vibrate. A small, very sharp knife, which cuts a groove upon a rotating wax cylinder, is secured to this diaphragm (membrane). A phonograph is therefore in a sense a lathe. (Fig. 1.)

As long as the membrane remains in a state of rest,

FIG. 5.—PORTION OF THE CURVE OF A FRENCH VOWEL.

the depth of the groove made by the cutting tool is constant, but when it is set in motion through the action of the sound waves, the depth of the groove varies, and as the tool is rounded off into a shovel-nosed shape, the width of the groove varies with the depth. (Fig. 2.)

It is possible to examine and study such a groove under the microscope, but for more exact work it is imperative that it be greatly magnified and transcribed upon paper. For this purpose Prof. Hermann utilizes a series of two or three small levers which actuate a small mirror. A ray of light falling upon this mirror is reflected upon sensitized paper, and thus the movements of the reflecting surface corresponding to the

a shovel-nose, similar to that of the cutting tool in Fig. 1, rests in the sound groove. It is secured upon a very long, light lever, and as near as possible to the fulcrum of the same. The distant end of this lever now follows the various undulations of the bottom of the groove according to Fig. 4.

The end of this lever inscribes every movement upon a blackened strip of paper stretched upon two drums. (Fig. 3, recording cylinder, blank cylinder.) This strip moves forward upon the drums in the manner of an endless belt, with the rotation of the recording cylinder. The curves, such as those shown in Fig. 5, are obtained in this manner from the tiny engravings upon the cylinder.

The shifting screw of the rotating device (Fig. 3) serves to move the cylinder sideways, so that the sound groove is always under the sapphire point of the lever. The degree of enlargement depends upon the length of the lever.

2. In the case of a gramophone record, a glass diaphragm is caused to vibrate in an analogous manner, and these movements are engraved upon a wax plate. (Fig. 6.)

The effective difference between this and the phonograph action consists in that the membrane is caused to vibrate laterally in the former case. In consequence, a groove of constant depth and with lateral undulations is produced upon the rotating plate. The hard-rubber disks of commerce are obtained from this plate by means of an intermediary matrix.

In order to transcribe the sound grooves of a gramophone plate, Prof. Scripture some years ago constructed an apparatus which to this day has not been improved upon. (Fig. 7.)

This apparatus consists substantially of a system of levers which transcribe the undulations of the sound groove in an enlarged scale upon paper. The gramo-

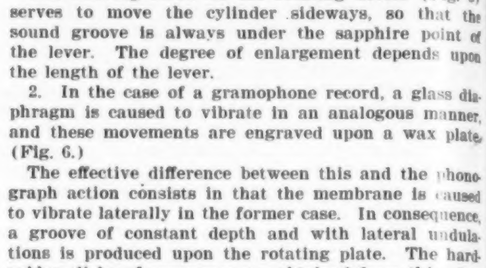


FIG. 6.—GRAMOPHONE RECORDING MECHANISM.

phone disk is secured to a rotator, and a metal pin, fastened upon an extremely long and light lever very close to the fulcrum, is placed in the groove. As the sound groove is engraved spirally upon the gramophone disk, this must be moved aside radially, so that the groove may constantly pass under the steel point as the disk rotates. This movement is effected by means of a screw, which causes the entire rotator to pass to one side. To avoid mistakes the movement

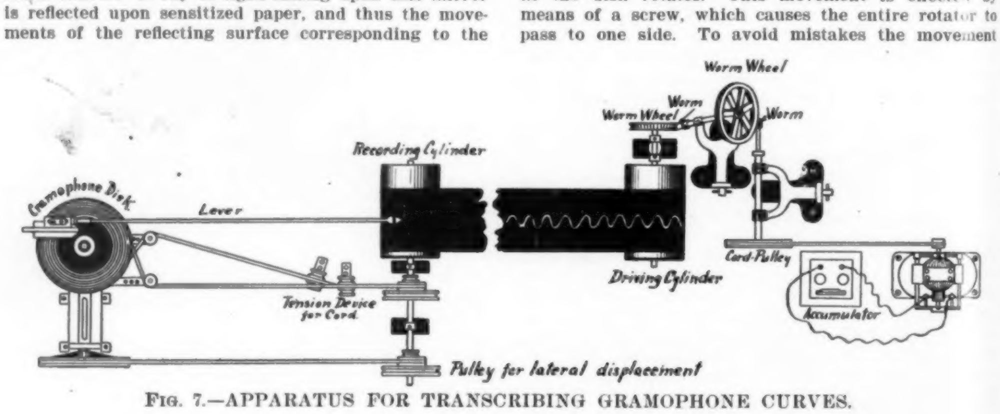


FIG. 7.—APPARATUS FOR TRANSCRIBING GRAMOPHONE CURVES.

magnified curves upon the phonograph cylinder, are photographically registered.

Prof. Scripture employs a different method. First a metal matrix is made from the record cylinder, and from this in turn as many celluloid cylinders as desired. A celluloid cylinder is secured upon the rotating mechanism of a specially-constructed apparatus (Fig. 3), and turned at a very slow rate, about once in ten hours.

The cord pulleys, worm and worm-wheels shown in Fig. 3, serve to transmit the movement of the shaft of a motor at a very reduced rate to the cylinder (about 1 to 28,800). A sapphire point fashioned with

must be extremely slow, and the disk must not revolve oftener than once in five or six hours. The enlargement is again dependent upon the length of the lever and the distance between the steel point and the fulcrum of the former. With careful handling a three-hundred-fold enlargement can be secured with certainty. The sound line is marked upon a long strip of paper in this apparatus (Fig. 7, driving cylinder) and the lines or curves thus reproduced are exact copies of the greatly magnified lines of the disk. To a certain extent the apparatus might be called a mechanical microscope. A single vowel is often several meters in length, and an entire speech kilometers long. To carry out the measurement, calculations, etc., the sound lines are cut out and glued upon pasteboard cards with extreme care.

Fig. 8 clearly shows groups of waves of the vowel *a*. Each group corresponds to an oscillation of the vocal cords in the larynx during the pronunciation of the vowel. The small subsidiary undulations within each group are due to the vocal organs, the cavities such as the chest, throat, mouth, etc. The length of a wave group represents exactly the duration of a vocal cord vibration. Under a magnifying glass, the groups in their order are measured to 1-10 millimeter. In Fig. 8 the exact wave lengths are given. A further calculation to determine the duration of the vibration (period) is then undertaken. From the rapidity of rotation of the original record, and from the relation between this and the movement of the paper in the ap-

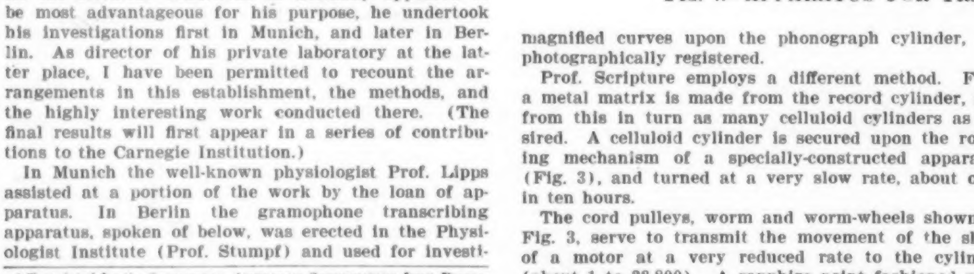


FIG. 3.—APPARATUS FOR TRANSCRIBING PHONOGRAPH CURVES.

* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

paratus, is obtained the time equation for the curves, which in this case is 1 millimeter = 0.0007 second; that is to say, 1 millimeter requires 0.0007 second duration of vibration. The number of vibrations calculated per second gives the so-called frequency. (Fig. 8.) If the pitch is now also ascertained, the graphical representation of the ten waves of the vowel *a* in Fig. 8 is shown in Fig. 9. The further calculations, such as, for instance, the determination whether or not the waves consist of pure sine-curves, are not discussed.

That each sound has its own peculiar wave form can be seen from the illustrations 10 to 19. Highly interesting are the curves of a yodler (Fig. 17), an orchestra such as Sousa's Band (Fig. 16), and of musical instruments (Figs. 14 and 15).

No two vowel-curves were found to be exactly alike in all the thousands investigated. This, however, is not astonishing, for are there two leaves alike in nature? But as each wave form corresponds to a particular sound, we must necessarily draw the conclusion that all sounds in some way or other differ. This also is not astonishing. A person with a good ear can distinguish an individuality not only in the speech in general, but also in each vowel, yes, even in a single cough. In spite of this, we are not aware that a person does not always pronounce the same word in exactly the same way. From the innumerable different waves, however, we may draw the conclusion that they are all shaped according to typical forms, and thus we

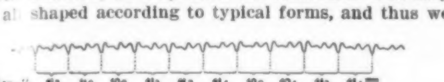


FIG. 8.—TEN SOUND WAVES OF THE VOWEL *a*.

obtain an *a*, *u*, *n*, etc., type. The final results, moreover (Figs. 8 and 9) give an exact picture of the melody curves and their rise and fall. Where the word "melody" is here used, it must be emphasized that this refers to a vowel, a word, or a speech exactly as it does to a song.

In this way the melodies of entire speeches were studied, including, for instance, an official speech of the well-known Senator Chauncey Depew (Fig. 12), a part of a drama by Joseph Jefferson (Fig. 13), a humorous recitation, a child's poem, "Cock Robin," etc. A systematic investigation of the melody of the poem "Der Fichtenbaum" was undertaken in this, and also in another manner. The verses, declaimed from memory, were recorded and then transcribed. Speech records were made of it as recited by inhabitants of Berlin, Lower Bavaria, Mayence, the Upper Palatinate,

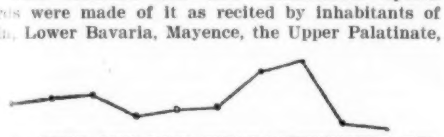


FIG. 9.—THE MELODY CHARACTERISTIC OF FIG. 8.

Austria, etc. The waves were measured, and the individual melody curves calculated and graphically represented. A comparison of the twenty different curves shows, despite individual differences, a general agreement of the melody. Each dialect has, however, its own melody forms; for instance, the North German speaks with falling intonation, while the Swabian exactly reverses the proceeding. Thus it is also that the Saxon sentence melody appears comical to the Prussian, and *vice versa*. Nevertheless, a general agreement was noticeable in "Der Fichtenbaum." This is probably explainable by the fact that in schools, at home, etc., literary compositions are generally taught and learned in one and the same melody. Thus there appears to be a commonly known melody type, just

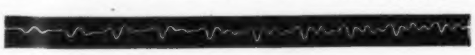


FIG. 10.—WAVES FROM THE BEGINNING OF THE VOWELS "*ei*" IN THE GERMAN PRONOUN "DEINEM."

as there is in the German free from dialect. It is probable that a poem is read by all Germans in about the same manner. Not only for the poetic art, but also for the national feeling, is the fundamental law of importance. Every educated German probably possesses feeling and love for Germany's literary treasures. A poet or an orator can surely depend upon it that the German will find the right melody in the text. If this were not so, the writing of a Bavarian, for instance, would arouse no proper appreciation in those who use other dialects. Does it make any difference that Schiller used the Swabian dialect, and that Goethe spoke Frankfort German?

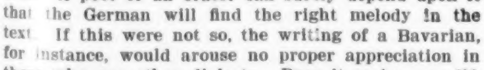


FIG. 11.—WAVES FROM THE DIPHTHONG "*au*" IN "AUGEN."

As the duration of the individual sounds is obtained, as explained above, by measurements and calculations, so also can determinations of the strength of these be made. According to Prof. Scripture's method, the three elements of the accent can be ascertained with exactitude by mathematical means, and this places the investigator in a position to delve to the very foundation of the poetic art. We may ask, for instance, is the modern art of versification founded upon variations in the strength (intensity, dogmatic accent), as is so often maintained, or is it substantially dependent

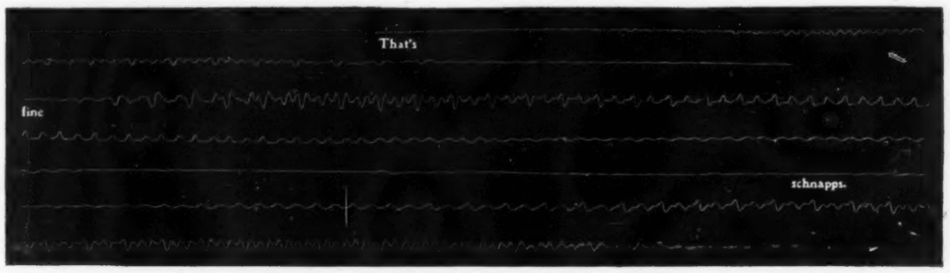


FIG. 13.—CURVES FROM "RIP VAN WINKLE," SPOKEN BY THE LATE JOSEPH JEFFERSON.

upon the duration (quantity) of the syllables? Does the pitch (the melody) play a part as in the Greek? As a result of these investigations, it may be said even now that the strength, length, and duration of a sound are essential parts of the accent in German, as well as in English, but not in the manner as it was hitherto believed. The essence of the poetic art must be looked at from another standpoint. Individual and distinguishable sounds and syllables exist neither for the poet nor for the hearer, and they must actually be regarded as products of the art of printing. This old, typographical conception must be replaced by a physiological one. The poet of to-day speaks his verses as if they were a current of sound in which certain regular measures or beats are to be expressed, and wherein the melody is carried out in accordance with his sense of duty. The verse of a true poet presents a work of art which is executed according to laws that are generally entirely unknown. The perception of his hearers is regulated according to similar laws. It is the task of physiologists and phoneticians to discover

FIG. 12.—WAVES FROM THE WORD "MY" SPOKEN BY SENATOR DEPEW.

these laws. Neither the poet nor his hearer is acquainted with them, in fact both should be ignorant of them. If, for instance, the poet thinks of the laws of versification, he loses those unembarrassed expressions of feeling which really make up the essence of poetry; the hearer, however, who automatically tests and studies the verses, will, it is true, prepare for himself a scientific treat, but will not have much attention left for the artistic side. The investigator of today must bury and forget the typographic methods in the modern science of metrics, just as the medieval scholasticism has been relegated to obscurity. These laws still exist merely because we *read* the poetry printed, and do not hear it phonographically; and secondly, because we *desire* to apply the laws of ancient metrics to modern poetry, notwithstanding that these should not be used at all.

It is incredible how many problems of phonetics besides those of the art of verse can be solved from the

FIG. 14.—WAVES OF A CORNET.

sound curves. For instance, wherein do the sounds of one language differ from those of the others, or what is the essence of the so-called phonetic basis of this language? What is the difference between the sounds of one speaking person and others, and wherein is the difference between speaking and singing? Wherein lies the vocal expression of the emotions? How does the vocal expression change in the course of the years? What a pity it is that the phonograph and gramophone had not been invented a few thousand years ago. How delighted we would be to hear an oration of Demosthenes or a recitation by Shakespeare! But not only to hear, but also to transcribe, analyze, and study. How important at the present are speech records of peoples in India, China, etc. Thus there are dialects which are used by only a few Indian tribes in North

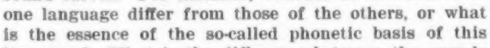


FIG. 15.—WAVES OF A CLARINET.

America, which will be totally lost in the course of a few years, and which should be preserved. Vocal records should be made of the speech of all the great men of our day, and saved for the future generations. Accordingly, His Majesty, Emperor William II., willingly permitted his voice to be reproduced by Prof. Scripture upon a phonograph cylinder, and this, in the shape of a metal matrix, is now preserved for all time in the archives of the Washington and Harvard universities. Prof. Scripture has also obtained permission to analyze this record of the Emperor's voice, the only one of its kind in existence. An atlas of sound or vocal curves prepared for each language would prove a mine of information for the sciences, and works of this kind have already been commenced in the laboratory of Prof. Scripture.

This, in short, has been the occupation undertaken in the laboratory, a highly interesting field, full of work, bold expectation, and decided successes. I cannot at present discuss the further labors with respect to a vocal organ, and the construction of vocal curves on a strictly scientific basis and their corresponding mathematical calculations.

METALS IN THE ATMOSPHERE.*

By ALFRED DITTÉ, Member of the Institute of France, Professor of Mineral Chemistry at the Sorbonne.

THE earth's atmosphere contains an enormous quantity of dust, particles of which float in the air for vary-

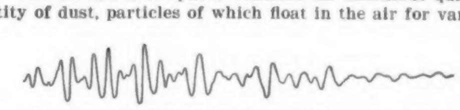


FIG. 16.—WAVES FROM SOUSA'S BAND.

ing periods of time. This dust is everywhere, in the fields as well as in town, and the only reason we do not see it continually is because the particles do not reflect enough light to make an impression on the retina. A ray of sunshine in a dark room reveals the presence of innumerable particles.

Any polished surface exposed to the air will soon be covered with an atmospheric sediment. All terrestrial substances, especially metals, may by mechanical action be reduced to a fine powder, light enough to be carried by the wind and held suspended in the air. The beating of the waves against the shore makes a powder, and the water in evaporating leaves a little saline residue in the air. One can imagine without much difficulty, but not without a certain disgust, the character of the dust particles found in city air; they form a means of contact between persons widely separated, and

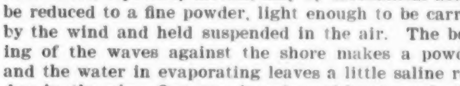


FIG. 17.—YODLER.

to this contact is due much of the disease common among great aggregations of people. Some of these innumerable corpuscles are bound to be germs of fermentations, of putrefactions, and of various alterations of the blood in epidemic diseases.

Not only are all these solid substances visible with sufficient light, but they may without great difficulty be collected for purposes of study. Pasteur was the first to devise a method of so doing by drawing the air through a tube containing a wad of nitrated cotton. When a sufficient quantity of air has been run through the air filter, the cotton, with its deposit of dust, is treated with ether, which dissolves it, leaving a residue of dust particles. The insoluble bits of dust are collected by decantation, washed and dried, and then examined under a microscope.

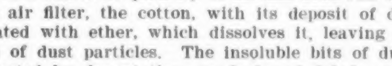


FIG. 18.—TYPICAL WAVES OF AN AMERICAN "*e*."

In this residue may be distinguished corpuscles of organic matter, with which we are not now concerned, and also mineral substances, which we will examine more particularly. Tiny as these bodies are, it is possible to measure them with a finely graduated micrometer, and it has been found that in diameter they ordinarily measure between one one-hundredth and one one-thousandth of a millimeter.

It is also possible to obtain an approximate idea of the quantity of these dust particles by drawing with an air pump a determined amount of air, bubble by bubble, through a tube containing a little pure water and then through a wad of nitrated cotton. The par-

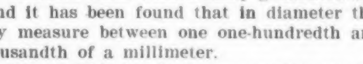


FIG. 19.—TYPICAL WAVES OF AN AMERICAN "*u*."

ticles which have been retained by the water are secured by evaporation and united with those obtained by the dissolution in ether of the guncotton. By this method there have been found at Paris, during normal atmospheric conditions, from 6 to 8 milligrammes of

* Translated from Revue Scientifique. Published in Smithsonian Institution's Annual Report.

dust to the cubic meter of air; after a day's rainfall, 6 milligrammes; after a drought of eight days, 23 milligrammes. Naturally the quantity in country air is much smaller. These figures represent the total weight of all solid particles, mineral and organic; if the latter be eliminated by calcination in a current of air the cinders representing mineral matter will be found to vary from 66 to 75 per cent of the whole weight. In the residue are found cinders of salts soluble in water, of matter soluble in hydrochloric acid, and of substances which can not be dissolved either in water or in acid.

The particles floating in the air are held there only by atmospheric agitation, the most minute being held longest in suspense. It may well be asked how bodies of this kind, so much heavier than the air, can be held in the atmosphere. Calculation will show that grains of mineral as small as 0.01 millimeter in diameter can nevertheless fall with considerable rapidity, 0.66 meter a second in the case of a gramme of silica. It can easily be seen that a sphere of 2.5 density, 1 meter in diameter, would fall at a speed of 220 meters a second, if the fall were uniform and through air of ordinary density. The theoretical velocity of a corpuscle of d dimensions would therefore equal $\sqrt{220d}$. But in reality this is greatly modified in bodies of minute dimensions by the agitation and continual movement of the air, which fact accounts for the suspension of the atmospheric particles. They do, however, fall gradually, and are continually forming on the earth's surface a sediment that can easily be collected by stretching on a frame a sheet of paper treated with gelatin and placing the contrivance on an isolated roof 10 to 15 meters from the ground. Or a dust table, about a meter square, lined with thin sheet tin and turning on an axis so as always to face the wind, can be used with equal success. The wind passing over its surface constantly lets fall a portion of the dust it carries, and this deposit is afterward collected with a flat hair brush. The quantity of dust varies with the velocity of the wind and the humidity of the atmosphere, also with the season of the year and the state of the sun.

In Paris between 2 and 9 milligrammes of dust are collected on a square meter of surface in twenty-four hours. Taking 4 milligrammes as the mean, this corresponds to a daily deposition on a surface equal to that of the Champs de Mars (about 500,000 m^2) of 2 kilos (4.4 pounds) of corpuscles. An estimate made by forcing air through water and evaporating shows a weight of 6 to 23 milligrammes to a cubic meter of air. Taking in this case 6 milligrammes as the mean and considering a sheet of air, say, 5 meters in thickness, there would be almost 15 kilos (33 pounds) of dust in an area equal in extent to the Champs de Mars and a weight of several hundred kilos in air overhanging Paris. In the fields the quantity of dust collected is considerably smaller. It is hardly necessary to say that this sediment does not remain long in the place where it falls, but is quickly carried off again by the wind. However, the figures given will indicate in a slight measure the importance and extent of this aerial transportation of solid matter.

High buildings act as veritable dust traps. For instance, in a tower of Notre Dame Cathedral which no one had entered for several years, the wind, passing through the narrow windows 60 meters from the ground, had deposited a bed at least a millimeter in thickness of fine grayish dust. Analysis showed that this was of the same composition as the atmospheric dust, i. e., about 32 per cent organic matter and 67 per cent of cinders. Of this inorganic matter, 9 per cent was soluble in water, 24 per cent in hydrochloric acid, and the remaining 34 per cent consisted of a residue essentially silicate. Various analyses of dust accumulated in uninhabited portions of lofty structures showed very similar results; the dimensions of the particles were invariably compassed between 0.01 and 0.001 millimeter, and the cinders always represented about 75 per cent of all the matter collected.

Another method of investigating the solid bodies in the atmosphere is by making an analysis of meteoric water. Rain is always charged with a sediment collected in the air, which may be extracted by filtering and evaporation. It can be advantageously collected in a receptacle made of a series of porcelain plates, built up on three sides only and arranged on a frame like tiles on a roof. If this apparatus be of sufficient size considerable quantities of water will glide over the plaques and through a funnel into a large flask. Porcelain is much better than glass for this purpose, as the latter is likely to be attacked by the carbonic acid and ammonia in standing rain water.

The weight of the residue extracted from a liter of water varies considerably. At the observatory of St. Maria du Mont (Manche) the sediment obtained by evaporation of several liters of rain water on June 1, 10, and 11, 1876, amounted to from 23 to 75 milligrammes per liter; at Paris it has run from 23 to 172, the maximum being 421 milligrammes. This residue is blackish gray, except that collected in the fields, which is entirely white, and it invariably contains the same relative proportions of mineral substances and organic matter.

The size of snowflakes and the leisurely manner in which these little spongy masses fall through the air make them even better fitted than rain drops to seize in their passage all the dust particles and solid bodies floating in the atmosphere. Moreover, solids are collected in the waters fused into the flake. Consequently, when M. Tissandier collected with all proper precaution the first snows that fell on the towers of Notre Dame in the winter of 1875, he found in each liter of the snow water a body of corpuscles varying in weight from 56 to 118 milligrammes. A liter of melted snow collected under the same conditions in the country contains from 48 to 104 milligrammes. Furthermore, as one might suppose, the corpuscles are less numerous after a prolonged snowstorm, so much so that in Paris, after a heavy fall, only 16 to 24 milligrammes were found. The residue obtained by the evaporation of melted snow is ordinarily an impalpable grayish powder, containing, at Paris, about 57 per cent of cinders, and in the country about 61 per cent.

Hail, because of its small size and its great density, does not collect the dust particles so easily. Nevertheless, it has been collected and examined in the same way.

Iron.—The examination of the cinders in the dust collected in these various ways enables us to recognize in our atmosphere the presence of a number of metals, the most important of which is iron.

When a strong magnet was held near some of the atmospheric sediment thus obtained, a portion of the corpuscles adhered to it and were brushed off for microscopic or chemical examinations. It was then discovered that these bits are made up essentially of iron. The same results were obtained with sediments collected in several very different localities. The examinations even went so far as to estimate approximately the quantity of iron contained in this magnetic residue by the intensity of the coloration of sulphocyanide of potassium in the dissolution of a known quantity of dust. These ferruginous particles were found to be either pure iron or that metal associated in certain proportions with other elements, such as nickel and phosphorus. M. Nordenskiöld, at Stockholm in 1871, examining the surface of the greatest fall of snow within the memory of man, found small quantities of metallic iron. But fearing this might have come from neighboring roofs, he had his brother examine the snow in a desolate plain surrounded by the forests of Finland. The black powder secured there was of the same character as that of Stockholm. The particles of iron drawn out by a magnet, when triturated in an agate mortar, were recognized as forms of the metal exactly analogous to those found in the snow at Stockholm and other parts of Sweden. Furthermore, there was collected on the floating ice off Spitzbergen a gray powder containing little magnetic grains of iron coated with iron oxides.

In examining some carbonaceous dust collected in 1870 on the snow and ice of the Inlandis glacier, a sea of ice in Greenland, at 80 deg. north latitude, there were found ferruginous corpuscles in which was determined the presence of nickel and cobalt. M. Jung has verified these observations by his researches on the snows of Geneva. He noted the presence of iron in the storm of 1883 at Geneva, on the Salève, and on the Great St. Bernard Pass, at an altitude of 8,100 feet. On the surface of the great snow fields covering this lofty region he discovered a very fine blackish powder containing the characteristic globules and irregular fragments susceptible to the magnet. The evaporation of 15 liters of water from melting this snow gave M. Jung a residue formed of the same particles, which treated with hydrochloric acid, made a solution with a strong iron reaction. The insignificant weight of the matter collected made it impossible for him to establish clearly the presence of nickel or cobalt. M. Nordenskiöld likewise observed some dust which fell at an altitude of 9,850 feet, near San Fernando, Chili, in November, 1883. The cordilleras, which had been white with fresh snow, were covered in the space of half an hour with a sheet of red, composed principally of minute ferruginous particles, hard but slightly malleable.

In this powder, which did not contain metallic iron, were found reddish-brown globular grains soluble in hydrochloric acid and brownish-white grains insoluble in that acid and made up of a silicate-like feldspar. The first named was composed of oxide of iron, 74.60; oxide of nickel with traces of cobalt, 6.01; silica, 7.60; magnesia, 3.88; with small quantities of phosphoric acid, aluminium, chalk, and traces of copper. The richness of the material in iron, nickel, magnesia, and phosphoric acid is remarkable. In contrast to this discovery, M. Tissandier, experimenting with rain waters collected at St. Marie du Mont (Manche), was able to obtain 124 milligrammes of corpuscles susceptible to magnetic influence, which, under the action of hydrochloric acid, left only an insignificant residue of silica, and found a solution in which ammonia precipitated an abundance of iron oxide, sulphocyanide of potassium gave an intense clear color, and even the yellow prussiate of potash a deposit of Prussian blue. The liquor separated from the iron gave with ammonium sulphide a light black precipitate of sulphide of nickel, forming with borax lead its characteristic pearl-violet color and turning to a brownish gray on cooling. M. Jung also collected snow at different altitudes—at 1,225 feet at Montreux on the border of Lake Geneva; 3,300 feet at the station des Avants below the Moutiers; at 8,100 feet at the hospice of the Great St. Bernard—and compared the evaporation residue from this snow with the dust collected in the towers of several cathedrals at Paris, Geneva, Lausanne, Varsovie, and at Samara on the Volga. He concluded that iron is as surely present in recent snows as in the dust of centuries accumulated in the clock towers of the old churches. In all cases the appearance of this metal indicated that it had been subjected to high temperatures.

These corpuscles, found always in greater quantities in the snows of lower altitudes than from higher regions, do not always have the same characteristics, and students of them have classified them into several groups:

1. Irregular amorphous grayish fragments, measuring from 0.1 to 0.2 millimeter in diameter.

2. Mammilated particles, black and opaque, much smaller, measuring only 0.01 to 0.05 millimeter.

3. Fibrous particles of about the same size.

4. Spherical corpuscles, black and opaque, diameter 0.01 to 0.02 millimeter.

5. Corpuscles apparently with a tiny vase-like neck.

Moreover, these minute ferruginous corpuscles divide into two classes, some which have been deposited on the surface of the earth, others of an extra-terrestrial origin. The effects of showers of meteors are shown in an incontestable manner. Ehrenberg, Arago, Quetelet, Daubrée, and Nordenskiöld have brought forward a great number of facts in this connection. Examining a fine dust which on the 25th of January, 1859, fell in the Indian Ocean, covering the decks of the good ship "Josiah Bates," Ehrenberg showed that this powder, which to the naked eye appeared to be only little agglomerate grains, was in reality formed by drops composed of metallic iron and iron oxide solidified and creased in a manner analogous to that of the Batavian tears. He considered this proof that a mass of meteoric iron is made incandescent by the friction of the air. Sediments of this sort may come from the superficial fusion of meteorites, or, as Daubrée has indicated in his memoir on the meteorite of Orgueil,* they may be simply the result of disintegration.

The dust is so friable that some bits were reduced to a powder by the pressure of the fingers. Its different parts are cemented together with some alkaline salts so soluble in water that this liquid will work a complete disintegration into a fine powder that will pass through the hardest filters. Numerous cases of rains of fire which should apparently be attributed to the fall of incandescent debris of meteorites are familiar. The Baron de Reichenbach insisted strongly on a granular formation of meteorites, which can exist as well as an impalpable powder floating in space as in the forms of conglomerates of several hundred kilos weight. Very small grains which, in passing through the atmosphere, were heated, melted, and volatilized, appear to us in the form of shooting stars; it is supposed that matter, not over a gramme in weight, is sufficient to produce one of these meteors. Searching for the dust of shooting stars, de Reichenbach found, in 186[illegible], on the summit of mountains of Germany some ferruginous dust giving nickel and cobalt reactions. On the hill of Labisberg, at an altitude of 1,300 feet, under the shelter of the beech forests, untouched by ax or pick, he found similar traces of nickel and cobalt. Again, in a note of March 4, 1812, Von Baumhaver published some observations on magnetic particles obtained from hailstones, citing particularly a hail storm he observed at Padua on the 26th of August, 1834. After this meteoric period of August and September Phipson managed to collect some black angular particles which were neither carbonaceous nor coated with soot, and which, dissolved in hydrochloric acid, formed a perchloride of iron. Nordenskiöld encountered in the snow collected on icebergs some metallic particles about a quarter of a millimeter in circumference containing metallic iron coated with carbonized oxide and was at the same time able to determine the presence of nickel and phosphorus.

After a heavy fall of snow at Geneva on October 5, 1883, M. Jung melted a quantity collected on the Salève, and found therein a deposit of powder exceptionally rich in iron globules.

There fell in 1883, about the annual period in November characterized by an abundance of shooting stars, a rain remarkably strong in metallic dust of cosmic origin. These particularly abundant globules of iron might have been produced by the breaking up of much larger meteorites into microscopical shooting stars. From his Stockholm analysis of snow, in which, as in hail, he found bits of iron, Nordenskiöld satisfied himself that hail is condensed around minute grains of cosmic matter floating in the air and falling imperceptibly but continuously to the earth. He regards the existence of such material as proven by his observations and attributes to its fall a considerable importance not only from the standpoint of the geologist and physiographist, but from that of the farmer; this last on account of its phosphorus, which with nickel and cobalt is characteristic of meteoric iron. To cite a single example: An analysis of the meteoric iron found at Santa Catarina, Brazil, gave the following components: Iron, 63.69 per cent; nickel, 33.97 per cent; cobalt, 1.48; with small quantities of phosphorus, sulphur, carbon, and silica. This iron, remarkable for its exceptional quantity of nickel, is not attacked by the action of air and water, and is recognizable by its smooth gray tint.

Nordenskiöld concluded from all the facts that a considerable number of aërolites constantly enter our atmosphere and are there broken up, thus giving an extraterrestrial origin to the magnetic corpuscles of the air.

The little meteoric particles do not, however, always appear in the form of polished spheres, nor in the characteristic globules. The iron floating in our atmosphere often appears in irregular black fragments formed by a conjunction of extremely minute granules grouped in compact masses sometimes with a rough and irregular surface.

The study of hailstones has led to the same conclusions as that of snow. In a hailstone at Stockholm, Nordenskiöld found some black grains which when ground in an agate mortar produced bits of metallic iron. In another case the hailstones had a metallic nucleus in their center. Everman demonstrated the presence of octahedrons of iron sulphate in some hail from the Prussian province of Orembourg, and Pictet recognized the presence of iron in the nucleus of hail-

* Journal des Savants, 1870.

stones which fell in the Majo Province of Spain. Hail collected at Padua in 1834 contained magnetic grains of both iron and nickel, a circumstance which connects them with the aerolites, since a combination of iron and nickel is a characteristic constituent of meteoric iron.

The apparent planetary origin of these aerial magnetic particles may best be verified by a comparison with filings from the surface of actual aerolites. Experiment has shown that the powder thus obtained and the corpuscles collected in the atmosphere are very similar. The fragments filed from the black crust adhering to the metal have the form of irregular little coated spheres. The cosmic particles obtained by Nordenskiöld showed a striking resemblance to those extracted with a magnet from the sediment of French rain.

All these observations establish the fact that much of the ferruginous dust found in the atmosphere comes from meteorites. These metallic masses hurtling through space are broken into fragments, throwing off incandescent particles of metallic iron. The lightest of this debris is carried through the air by atmospheric currents and falls to the earth in the form of magnetic oxide of iron, more or less completely fused. The luminous train of shooting stars is due to combustion of these innumerable particles, resembling somewhat the sparks thrown off by an iron ribbon burning in oxygen. Meteorites, as everyone has noticed, often have luminous trains, which are to be attributed to the incandescent debris detached from the mass.

Thus it appears that ferruginous powder of extraterrestrial origin is falling constantly to the earth and that a part of the atmospheric dust comes from planetary space. As Daubrée has brought out in his observations on the meteorite of Orgueil, some of these particles come from the explosion of meteorites or from their simple disunion when friable and prone to disintegration. Assuming that their mean diameter is a constant of 0.01 millimeter, which, in fact, is a rather too liberal estimate, it would take 2,500 of them to cover a square millimeter and 250,000 to equal in bulk a cubic millimeter. Therefore it is easily appreciated that the deposit of iron on the earth's surface from this source even in a considerable interval of time will not be great.

But, admitting that some of the iron dust is of extraterrestrial origin, it is equally true that a large part of it is swept from the earth's surface by the wind or carried up in the smoke of the foundries. In the neighborhood of these works may be collected globules of magnetic iron oxide, which, rising as sparks, took the globular form in cooling. It is easily shown that bits of iron at high temperatures become spherical, and that a mass of it combining at red heat with oxygen will divide into microscopic globular fragments. When very fine iron filings are made incandescent by passing through a hydrogen flame, they burn brilliantly. Tissandier has discovered, by collecting the products of this combustion on a porcelain plate and examining them with a microscope, that they are in the form of spherical globules, vase-necked spheres, irregular surfaced, or fibrous fragments incompletely fused. Powder obtained by striking a piece of iron with a flint is made up of the same kind of globules. An iron wire burning in oxygen will form globules of magnetic oxide visible to the naked eye and at the same time others much smaller, which may be collected in water at the bottom of the flask. These are visible only under great magnification, since their diameter rarely exceeds 0.01 of a millimeter.

The combustion of coal in factories furnishes the air an abundance of iron oxide from the decomposition of ferruginous pyrites contained in the coal. But all these particles obtained in the various ways mentioned, whether from the combustion of iron, coal, or other substances, are easily distinguishable from those of cosmic origin by the fact that they never contain nickel in any form.

Tilled land and salt water, whence gusts of wind snatch up particles the more minute of which measure scarcely 0.001 millimeter, often contain magnetic dusts in comparative abundance. A magnet passed over their surfaces attracts tiny grains of magnetic iron oxide. This is entirely independent of the particles due to the continual destruction of enormous quantities of iron in manufacturing. The dust from pulverized magnetic iron ore and other ferruginous minerals, or the dust formed by oxidation in open air or from fresh or salt water, never occurs in the mammilated, fibrous, or spherical forms. There are amorphic grayish powders which do not resemble those of planetary origin and are very different from those produced at high temperatures. Iron is also found in semi-transparent masses, green, yellow, or pink, mixed with opaque black particles. These M. Stanislas Meunier believes to have come from the debris of serpentine minerals—diorite, amphibolite, serpentine—containing granules of magnetite and always rich in oxidized iron.

But this terrestrial source of ferruginous dusts can not explain the extraordinary abundance of microscopic particles of iron found in polar and alpine snows and in rains collected in open country. The presence of this nickel-bearing iron dust can be explained only as a powder obtained from the surface of meteorites in the ways we have shown.

Metals Other Than Iron.—It follows, then, that iron is the metal most abundant in the air, and that in every case when its origin is extraterrestrial, it is associated in variable proportions with nickel and cobalt; but there are also other metals in the atmosphere. The analysis of their cinders, as already mentioned, shows that they are composed of some substances soluble in water, others soluble in hydrochloric acid, and some insoluble. The almost white sediments collected in the fields contain about 40 per cent of salts soluble in water, 30 per cent of such matter as calcium and magnesium carbonates, oxide of iron, and some insoluble substances like silica and clay, with small quantities of carbon.

An examination of the dust deposited in the towers of Notre Dame gave 67 per cent mineral matter, 9 per cent of which was soluble in water, 23 per cent soluble in hydrochloric acid (this decomposing into 6.1 per cent sesquioxide of iron, 16 per cent calcium carbonate, and 2.1 per cent magnesium carbonate, with traces of aluminium and phosphorus), and 34.3 per cent of matter, principally silica, not soluble in the acids. A grayish powder, fine and soft as meal, collected at Boulogne on October 9, 1876, contained in a dry state, besides 9.7 per cent of organic substances, 55 per cent of silica, 1.8 per cent aluminium (with traces of iron), 30.6 per cent calcium carbonate, and 2.5 per cent magnesium carbonate. In the ash calcium, aluminium, magnesium, and other metals were also found.

Besides their two principal components—iron and nickel—meteorites and their debris contain small variable quantities of cobalt, manganese, chrome, tin, magnesium, and aluminium. Some minerals in particular are contained in these bodies: Schreibersite (phosphide of iron and nickel), magnetite and chrome iron, which is sometimes found in considerable quantities in the form of tiny grains, and minute crystals, together with olivine and other silicates. In short, meteorites may be arranged in a long series, at one extremity of which are those composed chiefly of iron and nickel and at the other chiefly non-metallic mineral substances, as olivine, enstatite, feldspar, amphibole, pyroxene, variously associated. All of the meteoric minerals can be found in the dusts of the atmosphere.

Meteors may fall in a direction opposite to that of the earth's movement, in which case their relative speed, being the sum of the two movements, will be very great, perhaps 70 kilometers a second. The resistance of the air to a flight of such speed produces enough heat to completely burn and volatilize the matter. If, on the contrary, the movement of the falling mass is in the same direction as that of the earth, its relative velocity—the difference between the two absolute speeds—is scarcely 16 kilometers a second. In this case the heat developed is sufficient only to fuse the mass and vitrify its surface, then perhaps to break it in such a way as to form a meteorite or aerolite. It is not sufficient to make a shooting star with its great train of fiery particles. Consequently, in coming into the earth's atmosphere, aerolites, whether big or little, encounter a friction that generates heat and incandescence, consequently combustion, fusion, volatilization; condensation of the volatilized particles follows, and the dissemination of these condensed particles. Thus it is easy to understand how meteorites bring into the atmosphere various metals, free or in combination, and why metalliferous minerals, in corpuscles so minute that it is impossible to separate and identify them, may be found in the air entirely independent of the pulverized minerals raised from the earth's surface.

Matter Soluble in Water.—As already mentioned, the "cinders" of atmospheric sediments, when treated with water, always yield a certain amount of soluble salts. These are chlorates, alkaline sulphates, or calcium sulphate, and nitrates, particularly that of ammonium.

Ammonium Nitrate.—A drop of rain allowed to evaporate spontaneously on a bit of glass leaves crystals of various shapes on its borders as the corpuscles are drawn toward the center. A star with six points is well marked when the crystallization has taken place slowly; more rarely the crystals assume the plumule form. Ammonium nitrate frequently forms remarkable groups of crystals in the shape of crosses and swords, like those obtained by evaporating a drop of snow water. In no other manner can similar crystals be obtained, neither by varying the solution of the salts nor the method of evaporation. It will form only in regular crystals ramifying uniformly from a common stem or else in isolated prisms. Tissandier attributes this peculiar crystallization in meteorite water to some organic matter dissolved in the rain or snow. The evaporation of this water leaves in the bottom of the vessel a hard, fragile residue somewhat similar in appearance to coagulated albumen. Crystals of ammonium nitrate are easily recognized by their solubility in alcohol and by the fact that heat decomposes them without residue. Their presence in the air can not be verified, since, as everybody knows, nitric acid and ammonia unite readily to form ammonium nitrate.

Sulphate of Soda.—Sulphate of soda is frequently found in the matter soluble in water, and it crystallizes in four-sided prisms, like those formed by a supersaturated solution of that salt. It is only necessary to introduce into one of these solutions a few flakes of snow to determine immediately its crystallization. M. Goernez has shown that deposits from the most widely varied locations have this same property. Its presence in the air, however, is determined with less certainty than that of the more widely prevalent ammonium nitrate, and the atmospheric deposits show in every case the crystallization of a supersaturated solution of that nitrate. Not only has M. Goernez demonstrated that flakes of snow or solid atmospheric sediments will determine the crystallization of supersaturated solutions of soda sulphate, but that almost all bodies exposed to the air will do the same, showing that all these bodies contain traces of soda sulphate, somewhat difficult to detect by chemical processes, but made apparent by using supersaturated solutions of that salt as reagents.

The prevalence of soda sulphate is everywhere demonstrated, and since that salt exists in water, mineral, river, or sea, it is naturally found in the soil. Having a tendency to crystallize in a finely divided state on the surface of a porous body, the least wind will carry it off and deposit it elsewhere. Simple evaporation of waters containing sulphate of soda may perhaps account for its presence in the atmosphere. The same is true of any soluble body contained in water; the salt thus dissolved may be carried off by evaporation and be distributed in small quantities in the surrounding atmosphere. This has been proven in the case of perchloride of iron by evaporating a solution thereof above the boiling point of the liquid.

Still other causes favor the presence of sulphate of soda in the air. Sulphurous gas, sulphureted hydrogen produced in the atmosphere, is there easily transformed into sulphuric acid and on coming into contact with salt from the ocean produces a sulphate of soda. Again, the carbonate of soda in the presence of calcium sulphate, and numerous other sulphates as well, will give a soda sulphate and some carbonates. So it is established that sulphate of soda is formed in various ways and that in a humid porous body it crystallizes so minutely that the least puff of wind will scatter it everywhere. Whatever may be the origin of sulphate of soda, which is in the earth and water, it is apparent that sodium in that form is one of the commonest elements in the atmosphere.

Sea Salt.—Sea salt, which will crystallize in cubes on the evaporation of meteoric water, is also found in the air. Its presence was determined in melted snow collected on the lofty tower of Notre Dame in December, 1874. But residual dusts from melted rain and snow have no action on the supersaturated solutions of acetate, borate, hyposulphate, or soda sulphate, which shows that these substances, although efflorescent, are only accidental in the atmosphere. The same is true of nitrate of lime and calcium chloride, which are readily given up to the air, although their sources are not to be found in the atmosphere.

Accidental Substances.—Besides the dusts which the normal air almost always contains, there are those more exceptional ones of volcanic origin. Such was a dust which fell with the snow in Norway on March 29-30, 1878; it was gray and fibrous, formed of grains of 0.02 to 0.03 millimeter diameter. These were characteristic fragments of pumice and little grains of iron oxide in octahedron cuboids. There are numerous examples of the transportation for great distances of dusts, volcanic cinders, and ashes from great fires. For instance, the sand that fell on the western Canaries on the 7th of February, 1863, came in all probability from the Sahara, more than 200 miles. More recently the cinders from the great Chicago fire arrived at the Azores some forty days after the beginning of the catastrophe. The celebrated dry fog, which in 1783 covered all Europe for three months, first appeared at Copenhagen, where it continued one hundred and twenty-six days. It was caused by an eruption in Iceland. In September, 1845, a phenomenon of the same sort, but less formidable, was observed on the Shetland and Orkney Islands. This came from an eruption of Hecla on September 2, and the cinders had traveled more than 500 miles. The atoms that fell during the cyclone of 1879 in the vicinity of Naples and Palermo were tinged with yellow. In that region also have been found black spheres and globules, susceptible to the magnet, the diameters of which at Palermo were between 0.004 and 0.028 millimeter; at Naples 0.007 to 0.020 millimeter, and from 0.011 to 0.040 millimeter at Teramo. These measurements agree well with those magnetic spherules following on the coasts of Algeria and Tunis.

A shower of cinders fell in the vicinity of Etna from the 24th to the 29th of May, 1886; examined in the observatory of Palermo, they showed the little laminated crystals characteristic of the ejections of Etna. Similar phenomena have been observed after the eruption of Krakatao.

Conclusion.—Leaving aside the dusts which are temporarily brought into the atmosphere by volcanic eruptions or other accidents, we see that the air ordinarily contains only a small number of metals—sodium, calcium, magnesium, aluminium, and more especially nickel, cobalt, and iron. These have all a terrestrial origin, except the last three, which come from out of planetary space. The proportion of solid matter in the air does not appear great enough to be of significance in the physiography of the earth, but almost a third of it is composed of organic matter containing living germs. This part at least concerns the biologist and assumes some importance from its pathological consequences.

VENOM IN REPTILES' EGGS.

M. C. PHISALIX, of Paris, shows that the venom of reptiles is contained in the eggs, and seems to play a certain part in their development. He already pointed out that the eggs of the toad contained a certain number of the active principles of the venom, and drew the conclusion that these specifics had an important rôle in the phenomena of heredity. His new experiments seem to prove conclusively that this is true. He describes specially his researches upon the eggs of the viper (*Vipera aspis*). In this reptile the ovary commences its functions at the end of March, and if removed about the end of April we find in each ovary a collection of five or ten ovules whose large diameter varies from 0.08 to 0.7 inch. Cutting the ovule we extract a thick yellowish liquid. When this is diluted with water and inoculated in the guinea pig it causes effects which have all the characteristics of poisoning by the venom itself, a local swelling followed by progressive cooling and respirating trouble, ending in death. The substance which produces these symptoms

has physical properties identical with those of the venom. It does not pass by dialysis and becomes more liquid when heated. The quantity of the extracted liquid which is needed to cause death by sub-cutaneous injection is 2 cubic centimeters. Double the quantity of the blood is needed for the same effect, and it seems that the ovules collect the active principles of the venom which circulate in the blood. The larger ovules have more of it, and the small ones scarcely any. None of the other organs of the reptile collect the venom, the liver, pancreas, thyroid glands, etc., and when inoculated, have no effect. To sum up, the active principles of the venom accumulate in the ovules. It is probable that other specific substances also pass from the blood into the ovule, and that these substances, like the venom, have an effect in the development of the egg. If this is the case, the mechanical phenomena of ontogenesis are accompanied by chemical phenomena which play an essential part in the formation of the organs and in the mechanism of heredity.

THE DEMAGNETIZATION OF WATCHES.

By GEORGE M. HOPKINS.

THE chances of injury to watches by magnetization have been greatly multiplied by the development of the dynamo and its extensive application to electric lighting and other purposes, so that it is very common to find magnetized watches in the hands of persons having no connection whatever with electrical matters. A watch readily becomes sufficiently magnetized to derange its action and render it entirely unreliable. Proximity to a dynamo is not necessary to accomplish it.

The writer, after faithfully protecting a phenomenally accurate timepiece for years against the damaging influence of dynamos by leaving it behind while visiting lighting stations and other places in which heavy electrical currents were generated or used, suddenly found the watch behaving in a very erratic manner, gaining enormously one day and losing the next; but the strange action was not charged to magnetization, as great care had been taken to avoid it. After a week's stay at the watchmaker's, the timepiece was returned to its owner, together with a bill of five dollars for demagnetization. But for the undoubted integrity of the watchmaker, the bill would have been questioned. The remembrance of the free use of a permanent magnet about the time of the failure of the watch gave reasonable ground for the supposition that the watch might have received its magnetism from that apparently insignificant source. After demagnetization, the watch ran well, but it soon suffered its former fate. This time, however, the watchmaker did not receive five dollars. The writer, knowing the cause of the trouble, effected a cure quickly and without expense.

The remedy in this case is administered on the purely homeopathic principle, *similia similibus curantur*. If the watch is suffering from an attack of magnetism, magnetism must effect the cure, but such depends on how the curative is applied.

convolutions of No. 18 magnet wire (Am. W. G.). Its longer internal diameter is 2¼ inches, its short diameter is ¾ inch, and its width is 2¼ inches. The resistance of the coil is 1¼ ohms. Referring to the diagram, Fig. 2, the terminals of the coil, *I*, are connected with the studs, *G, H*, on which are pivoted the switch arms. The switch arms are pivoted to a vulcanite bar, which

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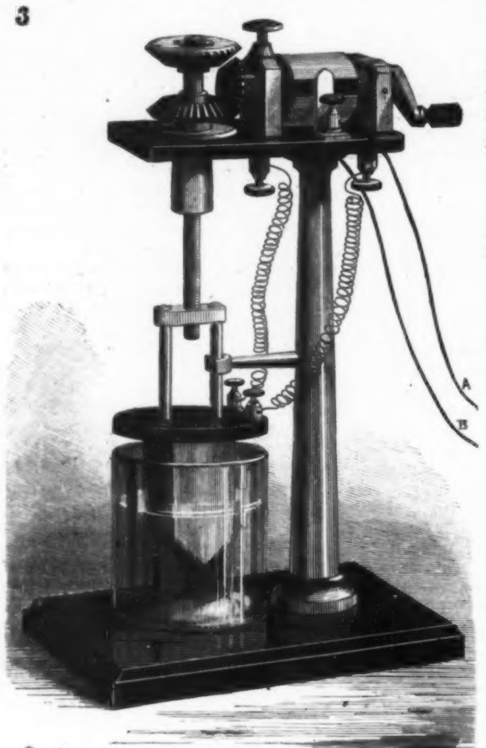


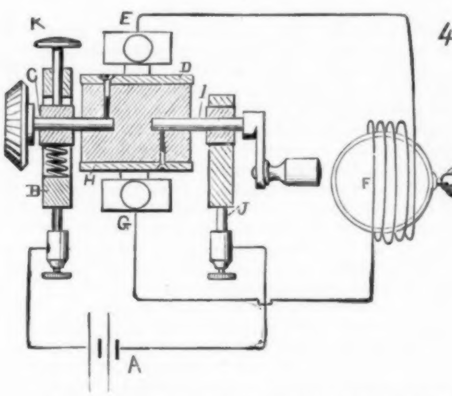
MACHINE FOR DEMAGNETIZING WATCHES.

maintains a uniform distance between them. To the base, and in the path of the free ends of the switch arms, are secured the contact buttons, *E, C, F*. The middle button, *C*, is connected electrically with the binding post, *B*, and the outside buttons, *E, F*, are connected with the binding post, *D*. The binding posts, *B, D*, communicate electrically with the poles of the battery, *A*.

The watch to be demagnetized is placed in the coil, and, while the switch arms are swung back and forth at the rate of about one complete excursion per second,

the uniformity with which the zinc of the battery is plunged and withdrawn. A considerable pause of the switch arms on one pair of buttons will exhibit its effect in the preponderance of the magnetism, due to the continued flow of the current in one direction during the pause. An irregularity of this kind will necessitate beginning again.

The watch is tested to ascertain, in the first place, whether it is magnetized and in need of treatment of this kind, and afterward to determine whether the treatment was effectual by presenting its different sides to a compass needle or, better, an ordinary cambric needle magnetized and suspended by a single fiber of silk attached to its center. The attraction of the needle by the watch is not positive evidence of its magnetization; but if one end of the needle is attracted by one side of the watch and repelled by the other side, it indicates that the watch is magnetic.



ELECTRICAL CONNECTIONS OF THE DEMAGNETIZING MACHINE.

The machine shown in Figs. 3 and 4 has been devised to insure the regular reversing of the current and the uniform plunging and withdrawal of the battery zinc.

The zinc and carbon plates of the battery are suspended by a yoke which is engaged by a screw arranged to revolve in a sleeve supported by the vulcanite plate attached to the top of the column. As the screw is revolved in one direction or the other, the yoke travels up or down on the screw, carrying with it the plates of the battery.

To the screw above its journal are secured two bevel wheels, either of which may be engaged by the pinion on the swinging horizontal commutator shaft.

The commutator is of the kind commonly used on induction coils. It consists of a cylinder of vulcanite mounted on a shaft divided in the middle into two halves, *C, I* (see Fig. 4), and having on diametrically opposite sides curved metallic plates, *D, H*; the plate,

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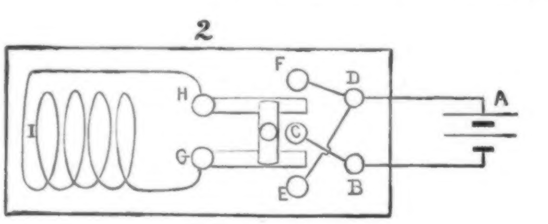

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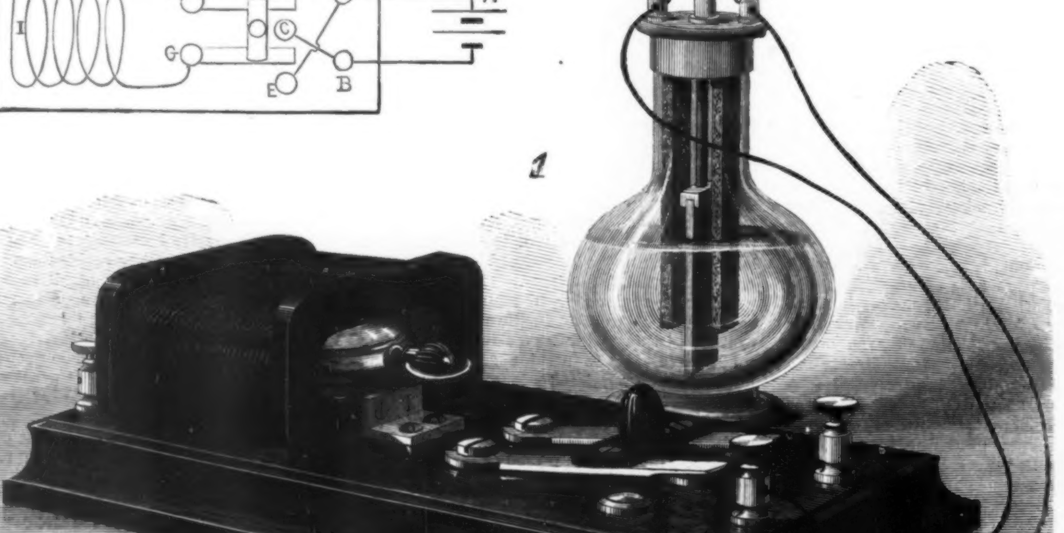


SIMPLE APPARATUS FOR DEMAGNETIZING WATCHES.

Fig. 1 shows simple apparatus for destroying the magnetism of watches. Fig. 2 is a diagram showing the electrical connections. Fig. 3 represents a demagnetizing machine based on the principle embodied in the apparatus shown in Fig. 1; and Fig. 4 is a diagram showing the electrical connections of the machine.

The simple apparatus consists of a flat coil large enough to inclose a watch, a current reversing key, or switch, and a plunging battery. One cell of Grenet battery is sufficient. The coil consists of about 225

the zinc of the battery is slowly plunged and as slowly withdrawn from the battery solution. When the switch arms touch the buttons, *C, E*, the current passes from the battery, *A*, to the binding posts, *B, D*, thence to the buttons, *C, E*, and through the switch arms to the studs, *G, H*, and coil, *I*. When the switch arms touch the buttons, *C, F*, the current passes in the reverse direction through the coil.

The success of the operation depends entirely on the regularity with which the current is reversed and

D, communicating electrically with the part, *C*, of the shaft, the plate, *H*, communicating with the part, *I*. The shaft, *I*, is journaled in a box pivoted in the standard, *J*, and is provided with a hand crank at its outer extremity. The shaft, *C*, which carries the pinions, is journaled in a spring-supported box arranged to slide in a mortise in the standard, *B*. The spring-supported box is provided with a knob, *K*, by which it may be depressed. Springs, *G, E*, which press opposite sides of the commutator cylinder, communicate electrically with

a coil, F, like that already described. The current flows from the battery, A, to the standard, B, thence through the shaft, C, plate, D, spring, E, coil, F, spring, G, plate, H, shaft, I, and standard, J, back to the battery. By pressing down on the knob, K, the pinion is

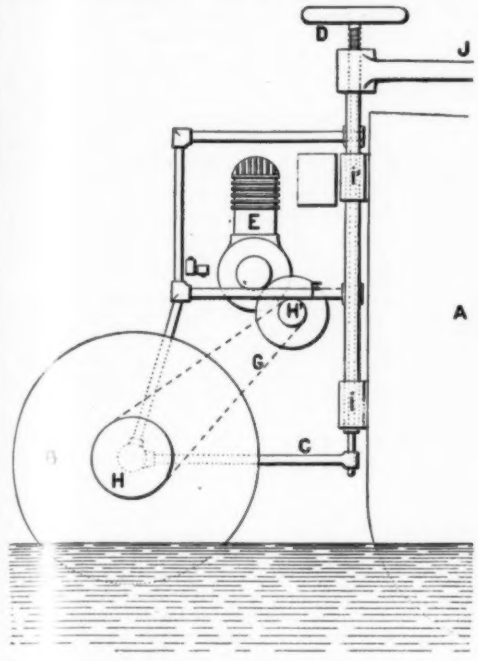


Fig. 1.—PROPELLER WITH RECTANGULAR FRAME FOR THE VERTICAL IMMERSION OF THE WHEELS.

A. Stern of the boat. B. Paddle wheels. C. Rod supporting the wheels. D. Hand wheel for regulating the immersion. E. Motor. F. Reversing and reduction gear. N. Transmitting chain. H. Paddle wheel hub. H'. Chain sprocket. I. Collar guides of the apparatus fixed to the stern post. J. Tiller.

brought into engagement with the lower bevel wheel on the screw.

If the crank be turned, the battery plates will be gradually lowered; at the same time, the direction of the current through the coil will be regularly reversed by the commutator. When the plates have been plunged sufficiently, the knob, K, is released, when the spring raises the commutator shaft and brings the pinion into engagement with the upper bevel wheel, and the screw is turned in the opposite direction gradually, withdrawing the plates from the battery solution.

To cause the solution to readily leave the zinc plates, they are made angular at their lower ends. This device also diminishes the strength of the current as the zincs are withdrawn. The connection between the battery and the standards, B, J, is made by means of spirals to permit of the free movement of the battery plates. The binding posts attached to the commutator springs are connected by wires, A, B, with a coil like that shown in Fig. 1.

If the first treatment of a watch does not entirely demagnetize it, the operation should be repeated without plunging the battery plates deeply.

A MOTOR PADDLEWHEEL FOR SMALL BOATS.

The Buchet establishment of Paris recently experimented in the Seine with a new stern wheel for propelling motor boats designed for the rapid transportation of a small amount of freight at a small expense.

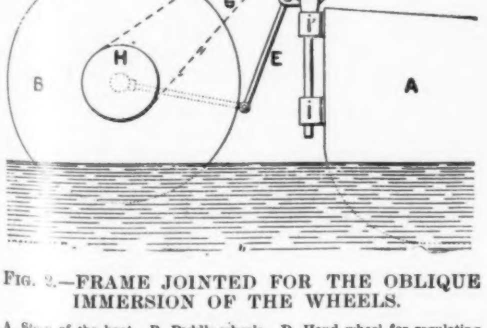
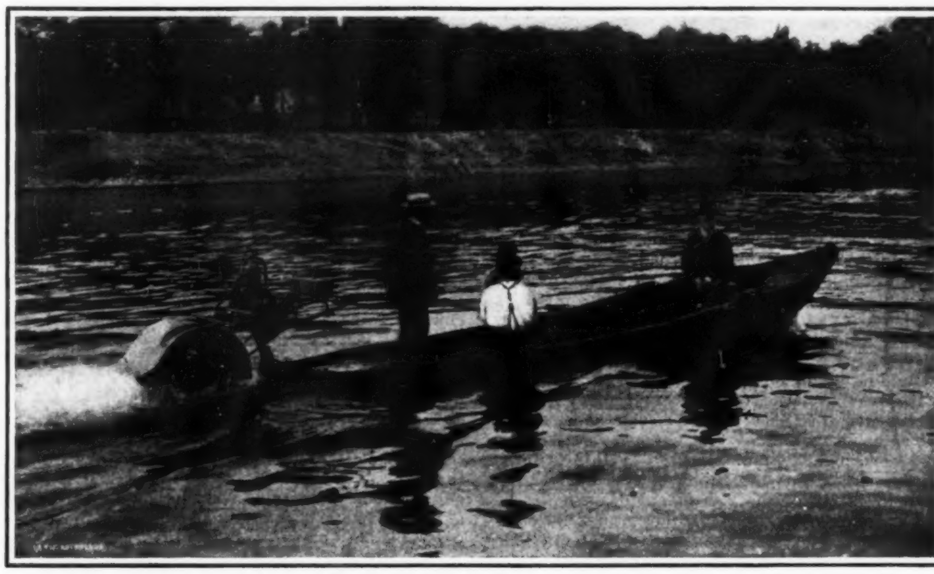


Fig. 2.—FRAME JOINTED FOR THE OBLIQUE IMMERSION OF THE WHEELS.

A. Stern of the boat. B. Paddle wheels. D. Hand wheel for regulating the immersion. E. Motor. F. Reversing and reduction gear. G. Chain. H. Hub. H'. Chain sprocket. I, I'. Guide collars. J. Steering bar.

The experimental apparatus, which weighed 220 pounds in running order, was mounted on the stern of a heavy fishing boat, which itself weighed when empty 3,300 pounds. With its 3½-horse-power motor, it carried a load of 4,400 pounds at a speed of 6.2 miles an hour.

The propeller, which is put in place and removed in less than five minutes, consists of a frame of tubing carrying the motor, the reversing mechanism, the fuel tank, and the sparking apparatus for the motor, and serving also as a support for the paddle wheels. This mechanical group, which is mounted on the stern, gives the boat the aspect of one of the gunboats of Tonkin designed to navigate in rapid water courses of



STERN-WHEEL BOAT ASCENDING THE SEINE.

slight depth. The propeller consists of two paddle-wheels, B (Figs. 1 and 2), keyed side by side upon the same hub. The motor, E, is a gasoline one with a vertical cylinder and a circulation of water around it and the explosion chamber. It gives an effective 3½ horse-power, and actuates a reversing and speed-reducing gear, which serves for the control of the paddlewheels. A friction wheel connects the motor and the reversing gear. The circulation pump, which is exceedingly simple, is directly actuated by the driving shaft by a simple rolling contact without friction, gearings, chain, or belt. This pump is capable of sucking to a height of 10 feet, and its discharge is amply sufficient to supply the motor with a circulation of water. It sucks the water from the river and the motor throws it back without interruption.

The reversing and unclutching of the propeller are effected by the simple change of position of a horizontal rod within reach of the steersman. The mechanism of this reverse apparatus, which is entirely inclosed in a tight case, operates in oil, without sliding gears or clutch. Two opposite frictions give the reversal of the direction of revolution. The revolving parts run on ball bearings, the balls of which are inclosed in tight boxes and operate in grease.

The frame of the propeller terminates in a tiller, J. The deviation is obtained by causing the angle of the vertical axis of the apparatus to vary with the

STERN-WHEEL BOAT DESCENDING THE SEINE.

vertical plane of the axis of the boat. This maneuver consists in turning the bar more or less toward the starboard or port, an operation that can be performed without the least effort on the part of the steersman. The latter has within easy reach a hand wheel that regulates the immersion of the paddles, a handle that regulates the sparking, a circuit interrupter, a handle to regulate the carbureter, and a crank for starting the motor. The reverse gear and the motor are lubricated by the same pump. There, is therefore, no maneuver that requires the steersman to change his position.

On the more or less complete immersion of the paddles of the wheels depends the expenditure of power and the proper running of the boat. One of the problems to solve in the construction of the propeller was therefore the regulation of such immersion, which is subordinate to the construction of the boat as well as to its freight. In order to satisfy these exigencies the inventor devised two apparatus of which we give diagrammatic figures. In Fig. 1 the immersing is done vertically along the sternpost, and is regulated by a screw that terminates in the handwheel, D. By turning the latter from right to left, the apparatus, guided by the collars, I and I', descends toward the bottom. A contrary manipulation raises the apparatus as a whole higher and consequently gives the wheels, B, less submersion.

In Fig. 2 the collars, I and I', do not perform the role of guides, but preserve their functions as pivots and supports. The screw that terminates the handwheel, D, produces, obliquely and through the intermedium of rods, a circular motion of small extent which determines the ascent or submersion of the wheels.

It is evident that such an apparatus, as handsome and as strong as it is, is not a definitive model, and the use of a boat of more industrial form would have necessitated another form of frame giving another outline to the mechanical whole.—Translated from La Vie Automobile for the Scientific American Supplement.

THE PRODUCTION OF PETROLEUM IN 1904.

Of petroleum and the drilling of oil wells there seems to be no end in this country. The production of last year was greater than that of any previous year. The total output of crude petroleum in the United States in 1904 was 117,063,421 barrels. The total value of all the petroleum marketed in the United States in 1904 was $101,170,466. The gain over the production of 1903 was 16,602,084 barrels in quantity and $6,476,416 in value.

These gains are so customary as to be commonplace. We might not know the figures, but we know that we should have been safe in forecasting the fact. It is, therefore, the minor features of the report about

which a student of statistics or a prophet of the future will be most curious. How came these gains? It appears even that the quantity of oil produced has increased two and one-third times in ten years.

Two new conditions stand out in the mass of facts contained in the 312 pages of data which Mr. F. H. Oliphant, the author of the United States Geological Survey's report, has collected. The most important of these is the fact that for the first time in the history of the petroleum industry the quantity of oil produced west of the Mississippi River was greater than that produced east of that river. New pools were discovered during 1904 in Texas, California, Kansas, Indian Territory, and Oklahoma, and many extensions were made to the old fields. In fact, an immense section, beginning in southeastern Kansas and extending southwestward into northern Indian Territory and Oklahoma, now over 180 miles in length and 50 miles in width, was proved to be locally productive of petroleum and natural gas. The possibilities of this great area and the effect of its output on the petroleum market constitute an important problem, the solution of which remains for the future.

All indications point to an increase in the production of petroleum in the United States for a series of years. Most of the petroleum produced in these western localities is, however, inferior in quality. It is not suitable for the manufacture of the most refined products, but its high heating value and its freedom from the more volatile constituents render it comparatively safe to transport and consume and make it a most valuable fuel.

The second notable fact revealed in this last petroleum report is that the automobile would seem to have set the pace for the rise in the demand for refined petroleum. According to the report, demand was made in 1904 "especially for the lighter grades used in internal-combustion engines of motors."

Many other interesting facts are set forth in this report, which is one of the government's free publications. It contains an account of the oil production in the United States by fields, States, and districts, with much historical and statistical matter, comprising statements concerning imports, exports, and prices of petroleum, as well as tariff duties, descriptions of methods of transportation, analyses of United States petroleum and its derivatives, and a discussion of the calorific value of petroleum. The last hundred pages of the report are devoted to an account of the operations of the petroleum industry in 1904 in the other countries of the world.

Mr. Oliphant's report is published as an extract from the Survey's forthcoming volume "Mineral Resources of the United States, 1904." Applications for copies should be addressed to The Director, United States Geological Survey, Washington, D. C.

A GLASS OF MADEIRA.*

By F. G. Aflalo.

The experienced traveler respects a well-worn maxim that he should, where possible, drink the wine of the country, extending, in fact, to his potations, moderate or otherwise, the excellent principle of doing when in Rome as Rome does. Very insular Britons resent such excursions into the unknown, and prefer, when conning the wine-list at their hotel, to halt at the familiar landmarks, ordering the usual pint of French claret or German hock for lunch, the usual pint of goodness-knows-what champagne for dinner, and the usual glass of alcohol and mineral water between whiles. To this category belongs also the healthy and patriotic type of islander who, spending the inside of a month in an interesting foreign country, forthwith seeks out his compatriots and in their company passes his days at cricket and his nights at bridge.

The more seasoned wanderer, on the other hand, indulges in the hitherto untasted products of the country. Should his travels lead him to the ocean paradise called Madeira, the very name points out the clear way. If he takes a furnished *quinta*, he must consult a wine-merchant in his quest of a light and inexpensive madeira ready for table use; if, on the other hand, he intrusts his comfort to the Palace Hotel, the very first page of the wine list gives him a round dozen for choice. He need go no farther; he need not seek out the Moët or Pommery; for the Pommard and Chambertin he will spare a friendly nod of recognition and no more; he will cold-shoulder the Liebfraumilch and Marcobrunner; the Lafite and Margaux he will, with the rest, leave for the fullness of his days at home. For the moment let him daily with the madeiras, most of them worth sampling, yet none, perhaps, inviting lifelong devotion to the exclusion of other wines. Other Portuguese, but not island, wines are given on a later page: Bucellas and Collares, excellent light table wines for hot weather, mixing well with mineral waters, and making an admirable groundwork for "hock-cup." The madeiras proper range in price from eighteenpence to two lawyer's fees the bottle, and frankness compels the admission that there is one of them in whose company I would rather sit for half an hour and pay, than enjoy gratis a week of that of either my own lawyer or the solicitor-general.

Other skies, other habits. Madeira never appealed to me at home. Like sherry, its place in the well-ordered life seemed as an adjunct to turtle soup or to purées of humbler antecedents. To drink a couple of glasses between meals would, in hot weather or cold, have struck me as cold-blooded, wanton tippling. Never again shall I look askance at the man who welcomes a glass of madeira after a hot ride. Outside the island itself I know not whether even now such preference would appeal; but at the English rooms in Funchal, in a certain cool wine cellar in the presence of venerable butts and octaves, and in a lovely *quinta*, its garden ablaze with flowers and aquiver with the bubbling music of rare captive birds, the juice of the local grape has many times attuned mind and body to a mood of perfect peace.

There is of course madeira and madeira. Memory recalls a glass of very thin brand, swallowed hastily (else it had never been swallowed at all) during a hot ride through Cama de Lobos, the center of a busy wine district. Quaffed in the saddle on a sunny afternoon of May, it pleased despite its faint bouquet and meager body. Memory recalls also a glass, several glasses, taken with more fitting deliberation, in a cellar in Funchal, a '68 wine of beautiful character, a wine just two years older than the throat down which it trickled like a liquid poem. Madeira is not a wine to take quite seriously, like port. All these Atlantic archipelagoes produce wines with which to trifle soberly. Six or seven years ago, when staying at Orotava, in the Canaries, a friend and myself started at either end of a long list of native wines. These were without exception inexpensive; also, we took no more than a wine-glass of each, and tasted only such as were quoted in half-bottles. My friend climbed up, and I climbed down, until each had struck something to his taste and stubbornly refused to move farther, so that the middle dozen went untasted.

The hotel at Funchal does not offer so wide a range in madeiras. Half a dozen malmseys (one dated 1790, and a second the year of Waterloo), a couple of tintas, a sercial, and a bastardinho are among the most interesting, though not all will suit the same palate. The season of the vintage is August and September, a little earlier on the south side of the island, a little later in the shadier north, and the overladen vines are then relieved of their great bunches of red and white grapes, which are trodden in the press and crushed by the beam, the must, collected under the supervision of an employe of the exporter, going straight to the store in skins. These have to be borne thither on men's shoulders over steep and narrow mountain-tracks that allow of no other portage. Fortunately, the very stiffest of these goat-paths are outside the route of the wine-carriers, for the vine is no plant of the peaks, flourishing only to a reasonable height above sea level, so that it clothes only the feet of the sublime Pico Ruivo, the summit of the island, Madeira's closest intimacy with the empyrean. Some of the finest vineyards are situated on the high ground west of Cama de Lobos, one of the most picturesque fishing ports on the south coast; and both red and white grapes are used in making madeira, the only other native wines being a little muscatel and a rough red claret from the northern districts.

The age of fast steamers has not been without its influence on Madeira's wine industry. In olden times, when a sailing ship took months to cover the distance between Falmouth and Funchal, the wine was shipped in a crude state, and the heat of the hold was, on so long a voyage, sufficient to bring it to maturity, though this system entailed a wastage of anything up to 10 per cent. Some of the finest wine cruised east to Calcutta or west to Jamaica before reaching the merchants in Leadenhall Street. To-day, however, when Union Castle steamers exchange the mud of Southampton for the crystal water of the Funchal anchorage in little more than three days, and when even cargo steamers link the vine-clad island with the cold lands of the North in twice that time, the wine is brought to perfection in the land of its being, and shipped thence ready for use. The exporter, that is to say, keeps it in the wood for several years, heating it artificially during its early stages, clarifying, fortifying, and otherwise improving until in a fit state to dispatch to its dwindling admirers abroad. Some of the cargo boats take it *via* Lisbon; others voyage direct to the Baltic ports—for Russia, even in her times of stress, is among its warmest supporters. The bulk goes away in wood, in hogsheads or octaves, or even in smaller measure, but a few private orders may go in bottle. Having been laid down in wood for three or four years, it may be kept in bottle for as long as the term of its owner's patience, steadily improving in quality and not deteriorating like many wines of other character. Decanting should be done by one who knows how, and a uniform temperature should be insured between bottle and decanter if the delicate liquor is not to suffer by the change of quarters. This is the day of the large shipper, and a couple of English firms, one established at Funchal so long ago as the time of the Forty-five, probably share about two-thirds of the entire export trade.

That this is what it was no one pretends. It has lasted at any rate for four centuries, and the vine, originally introduced from Crete, has in that period made itself thoroughly at home on the lower slopes of these volcanic hills. Yet a wine cannot lose its vogue in so wealthy a land as Britain without suffering, and the United Kingdom no longer counts seriously among its customers. Edinburgh, once a strong supporter, knows it no longer. Time was when a maiden aunt brought out a glass of rare madeira for her favorite nephew, and old sea dogs who basked out the sunshine of their day in trim cottages on the Devon coast would keep a dozen bottles over from their last voyage and bring one out on state occasions for their cronies. To-day all this is changed, and champagne and port will soon be the only wines found in the average English country house. Here and there, however, a conservative tradition keeps madeira in its place of honor; and there is at any rate one hospitable mess where every evening the port and sherry go round the dinner table untouched.

To essay any explanation of these changes of fashion is hopeless. The fault is not in the wine, for there is as good in cask to-day as ever went across the ocean. It is simply out of vogue. And since even in our cups we are sheep, it would quickly regain its popularity with us if only patronized by those whom lady novelists love to describe as "very august personages." France, Denmark, Russia, and the United States are still good customers.

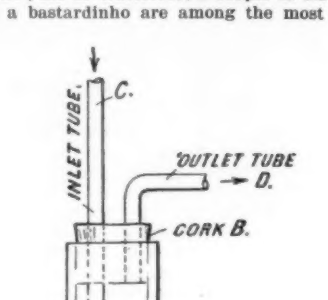
The report for 1904 by Mr. Vicars, the British consul, bears this out, and shows a considerable decrease in the export of wine from Madeira from the previous year. From one cause or another, he says, madeira wine has gone completely out of fashion at home, partly, no doubt, by reason of the ever-increasing favor of lighter wines, but also in great measure for no other reason than that it is no longer a fashionable wine. He mentions a case of a private importer who invariably passed off his madeira as brown sherry, under which name it was exceedingly popular with his guests, who, he maintained, would not have touched it had the decanter been labeled madeira.

* Chambers's Journal.

A THERMOSTAT FOR AMATEURS.*

By Edward F. Chandler.

A device for controlling the temperature of drying ovens, incubators, and kindred apparatus may be found in the catalogue of almost any laboratory supply house under the heading "Thermostat." Although a cut generally accompanies the brief catalogue description, there is seldom enough detail to assist in the construction of one of these instruments.



A THERMOSTAT FOR AMATEURS.

That this important little piece of apparatus is very simple will be seen from the description of the accompanying sketch, which shows the complete arrangement. As the sketch is in its proper proportions, I will not give figures, as it is quite impracticable to attempt to anticipate the demands of each individual case. I might suggest, nevertheless, that for general use in connection with an oven of about 500 cubic inches capacity a body tube 2½ inches long and about ⅝ inch inside diameter is very satisfactory. The bulb should be in this case about ¾ inch diameter outside. The body, *H*, is made of tough annealed glass tubing. In the top is a cork stopper, *B*, with two perforations. Through one is inserted the supply tube, *C*, which is ground off at an angle of about 45 deg. at the lower end, *c*. The other perforation holds tube *D*, which is the outlet tube (and is connected with the Bunsen burner by a rubber tube). This tube is set in flush with the lower surface of the cork. At the lower end of the body is a rubber stopper with a single hole, fitted with the stem of the bulb tube, *E*. The bulb tube is bent so as to allow the mercury, *F*, which about half fills it, to rest over the capillary opening in the stem. The space, *G*, above the mercury contains air, upon the expansion of which depends the working of the instrument. The filling of the bulb tube is similar to the making of a thermometer (very nicely described in these columns of some time back). For the benefit of those who missed this article, the following will be a help: Seal the end of a piece of capillary tube about 8 inches long; heat the sealed end in the flame of a blow-pipe, and when soft remove from the flame and blow steadily into the open end until the proper-sized bulb is obtained. Now heat the neck of the bulb and bend same to the required shape. Allow the piece to cool gradually, then score with a file and break off the tube to the desired length. The finished tube is next

* Specially prepared for the Scientific American Supplement.

inverted, allowing the open end to dip into a cup of mercury. Applying heat to bulb will drive out most of the air, and if the end is held under the mercury until cool, some of the quicksilver will be drawn back into the bulb and stem, which completes this member. The next operation is to insert the end of the bulb tube in the lower stopper (see sketch) and to put a little mercury in the reservoir as shown. It will now be seen that when a gentle heat is applied to the bulb the air expands and pushes the mercury through the capillary tube into the reservoir, which in turn rises, and upon coming in contact with the end of the tube, *C*, closes the opening at *e*, making a valve, which would shut off the gas, if flowing in at *C*, the supplying tube. The tube, *C*, is drawn up or pushed down so as to shut off at a predetermined temperature, and therefore, when the oven starts to overheat, the mercury rises and entirely or partly closes the inlet. The grinding of the end of *C* to 45 deg. makes the change less abrupt. As the thermostat would entirely cut off the gas supply when above the required temperature a small auxiliary burner is supplied which burns continuously and relights the heating jet upon the opening of the valve. In this way a regular temperature may be maintained for an indefinite time.

EXPERIMENT WITH ELECTRIC SPARK.

THE source of electricity to be employed is, at a minimum, six bichromate of potash elements, or six Leclanché elements, or, better still, a small Gramme magneto-electric machine. The experimenter, having found that whatever be the interval that separates the copper wires fixed to the poles of the source, no electric spark jumps between them, may produce what is called the interruption spark. The experiment may be rendered more brilliant by means of quite a coarse file, *L*, the extremity, *A*, of which is connected with the pole of the electric source. The negative wire is grasped by the insulating part and its extremity is moved quickly over the ridges of the file. Brilliant sparks are obtained, particles of iron are volatilized and handsome bluish gerbs are observed. These luminous effects will become still more intense if the extremity of the wire terminates in a small brush made of fine copper wire.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Science au XXme Siècle.

IMAGININGS IN A MOUNTAIN OBSERVATORY.*

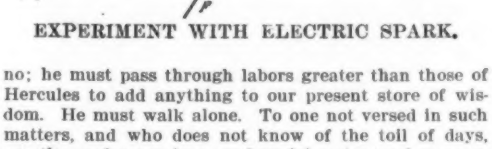
1. THE average temperature of the earth has been decreasing continuously throughout all periods of geological time.
2. It will continue to lose heat until all has escaped into space.
3. The sun is a medium-sized dying star.
4. It will lose all its heat.
5. The earth can be destroyed by a comet.

Here are three possible ways in which the human species may be annihilated. It is certain that the race will be totally destroyed. We are, therefore, not permanent in nature. We have no abiding city, and are sojourners. The sun has passed the zenith of its glory, is no longer white-hot, and is cooling. Human beings are mere creatures of temperature. It is surprising to see how slight a change either way in solar heat would end our career on earth. The earth has passed through vast changes in temperature. Formidable glacial epochs have occurred. The last one killed many millions of enormous animals, for tons of bones now fill ancient caves, and are buried in the drift. If men lived then, they died along with their animal associates. No proof is had of vast antiquity of man; he belongs to the geological age known as the Recent. That is, he appeared after the sun began to die. For without doubt he could not have existed when the sun was pouring out its heat in maximum floods. The career of man is evanescent indeed; vast cosmical energies must cease raging, and almost the hush of silence obtain, that he might come. A mere breath, a slight period of solar turbulence, can at any time terminate our existence. If we ascend the highest mountain we die with cold; or descend to the deepest mine, we expire with heat. Thus we are living between two sides of a thin film. We cannot escape. The chemical constituents of our bodies have slight affinity, and can be separated easily. And it is exceedingly easy for that pair of inscrutable mysteries, life and mind, to fly away from their unstable home. Man with a reasoning mind is therefore of comparatively late appearance geologically, though the time since he stepped upon the cosmic stage is long in years. Thus mind is the latest and most refined product of the mysterious laboratory of nature.

MIND.

I am never alone on the mountain and under the silent stars without thinking about the marvels of mind. The new science, mentalism, is as fascinating as astronomy. And it is more complex. The enormous mail received here reveals the fact that strange mental phenomena are happening. And they are increasing; or, at least, more are recorded. Twice I have written in the English Mechanic that the top of a mountain is a wonderful place. All alone and at night! And the profound mystery is deepened beyond all computation by the telescope. An incredible thing about it all is that it does seem as though Nature ought to speak. There is an inexpressible fact about mind wholly unknown to man at present. I expect any day to hear that some mentalist has made a startling discovery. Oh! if human beings would only study harder, find out more of Nature's laws, and then obey them! How many more centuries must pass before men see that they must obey the laws of nature, or surely and inevitably suffer the consequences. People think they can break the laws of nature and escape results. This is utterly hopeless.

"Man is, from a purely structural and animal point of view, very closely united with the animal kingdom. He has no department of his own, but belongs to the Vertebrate department, along with quadrupeds, birds, reptiles, and fishes. He has no class of his own, but belongs to the class Mammalia. Neither has he an order of his own, but belongs to the Primates, along with monkeys, lemurs, etc. But from the psychical point of view it is simply impossible to overestimate the space which separates man from all lower things. Man must be set off not only against the animal kingdom, but against the whole of nature besides, as an equivalent." (Le Comte, "Geology," p. 629.) Here a great scientist places man equal to all else in nature. It is true, good mathematicians and other revealers of nature's laws are equal to all nature beside. Now, if the base of nature is mental, or if this mind has a trace of analogy to the human kind of mind, it is incredibly unaccountable why no information is ever given to waiting man. Kepler toiled seventeen years to find his three laws. Newton labored year after year to discover gravitation's majestic laws, and all discoveries come from arduous labor. Many students wear their lives out in research, adding a point or fact, and then die. It costs dreadful toil to bring a law of nature to light. The steam engine, railways, telegraphs, telephones, printing presses, and mathematics, and everything we have, upon which civilization is based, is due to severe labor. The standing mystery is, Why does not Nature speak to her child? That is, if she is mental. If not, their inquiry is useless. Man being equal to all other things in nature, does not need to worship. Adoration is now obsolete. Man with a normal mind cannot help loving those glittering gems—those diamonds, rubies, sapphires, opals and pearls—all suns piled on suns by the billion; also the circling planets in space; nor this beautiful world, the earth, with its mountains and tossing sea—even if they will not speak to him, but remain as mute as the stony lips of the Egyptian Sphinx. How man longs for Nature to become articulate and give him some hint, some help in the solution of her riddles. But



EXPERIMENT WITH ELECTRIC SPARK.

no; he must pass through labors greater than those of Hercules to add anything to our present store of wisdom. He must walk alone. To one not versed in such matters, and who does not know of the toil of days, months, and years in a modern laboratory, where men actually wear their lives away in search after nature's laws, it is perhaps well to say that the human frame has not been subjected to such tests of endurance in all history. But, if possible, they must henceforth work harder than ever. The ship of Science is now scarcely out of the harbor, has not "crossed the bar," and is not yet fully "launched in the deep."

I am well aware that my language in letter 287 is severe, and that some readers were shocked. But really, I am taxing my strength for the benefit of mankind, and for the dissemination of the sweet, the good, the pure, and the true. It pains me to see man crouching and groveling in the dust, in puny worship. It is all unnecessary and not required. For twenty days I was with the chief representatives of the human species, the highest that have appeared, at the great Congresses of Science in St. Louis. I was in a room with eighty-two of the chief mathematicians on earth. Each one could weigh the earth, the sun, and stars. The vast mechanics of the universe was an open book to them. And in the World's Congress of Electrical Engineers I saw men who are able to "wire" this planet and make it an electrical home of beauty and happiness for all mankind. I attended, perhaps, a hundred of these meetings, where 980 men, all told, with mighty intellects, grappled with Nature, struggling to wrest her mysteries away. They wanted to find more laws, to be applied to the betterment of man and increase of his happiness. Not one of these meetings opened with prayer; supplication was not heard: work was substituted. And the highest of the human race filled the rooms. The present vast expansion of mind cannot be much longer chained by cancerous creeds, catechisms, corroding confessions of faith, or bibles. Science, natural law, and truth will burst all festering bonds, and the mind will at last be free. Positively, creeds are absolutely useless in the twentieth century—the century of the reign of mental law. An established church is a national incubus. All hierarchies must go soon; and will, except that hideous monster, the hierarchy of Rome. It has its awful clutch on the throat of man, and hangs on with the grip of a tiger.

MIGHTY CHANGES NOW ALMOST HERE.

The existing order must be upset. First cut every church steeple down to the roofs. Remove the cross, that priapic emblem of an age of savagery, from the sight of man. Turn half of the churches into lecture halls and scientific laboratories. Have moving pictures of natural world-wide scenery; of cities, and all races of the earth in panorama. Have lectures giving the new discoveries to date. So much labor-saving machinery is now in use that holidays could be had every sixth day, and then do the world's work. Perform all kinds of electrical, chemical, and physical experiments for the blessed children. Project the wonders of the world of the microscope on the screen. Teach the laws of Nature in easy lectures, every statement illustrated by pictures, so the little tots could get glimpses of the splendors of Nature. Teach temperance and rigid morality. Burn the catechisms. No set of words ever written are so deadly and terrible. I read two to-day—the Methodist and Presbyterian. Human ingenuity cannot sink thought to more terrific and appalling depths. Human reason stands aghast before the hideous language where innocent children are said to be cursed with "original sin." How much more beautiful to show the little ones the teeming life in a drop of water, or the wonders of a flower or leaf. Ransack nature for the children. I have lectured to the dear boys and girls, and so intense was their interest, with stereopticon, electrical experiments, and the microscope, that they were unconscious of the flow of time. And I have seen suffering just as intense. I have seen the fires of hate and rebellion rising in the hearts of youth when cursed by the catechism. The other half of the churches I would turn into theaters. I would make the drama a majestic science, and would let each child in the entire nation take part in moral dramatic scenes, with music, art, and all good things galore. The awful horrors of the catechism would never be heard by a child if I had my way. Their young lives would never be saddened and crushed in blackened gloom by hearing of a raging God and imaginary hell. The suffering of children and young people all these horrible centuries, caused by being deprived of the glories of this lovely world one day in seven, and forced to study mind-killing, brain-curdling catechisms, has been so terrible that description is useless. I have suffered these horrors myself, and know whereof I speak. I would make every sixth day a national legal holiday, given up to the enjoyment and happiness of the people. From 10 A. M. to noon I would have highly-entertaining illustrated scientific talks to the children, with a wilderness of instruments, microscopes, electrical and physical experiments, biological and botanical. The young people would take part in the highly interesting manipulations. Every known kind of scientific instruction would be given in popular language to adults in every dismantled church. The people would hear of every advance made by humanity every sixth day. They would become twentieth century people, with intelligence beyond comparison. I would drive horror and gloom of savage, bloody religion from the fair face of the earth. "Sunday schools," like these here described, are now springing up in many places in the United States. Interest is so intense that children beg to attend. No allusion is made to religion; prayer is never heard. Light gymnastics, marches, graceful drills, with posing and culture, have been substituted for silly, senseless, useless prayers. Music is always round about, with singing. And you ought to see happiness glowing and beaming on the faces of the children, and the light of joy on the features of their parents. These are not called Sunday schools, but lyceums. They have reached a responsive chord in the human mind. From noon to night the time I would have the people pass in social entertainment, visits, excursions by rail and boat, games, athletics, and other means of securing happiness. All brutal things, like fighting of men or animals, and of racing horses until their hearts burst, I would punish by imprisonment in the penitentiary. I would eliminate primitive savagery from the mind of man, and substitute enlightenment, and mercy. In the lyceums, where tried happiness surpassing any known to children before reigns supreme, they never hear of hell, catechism, creed, or any nameless horror of the past. I would as soon draw the children into line, and give each a bottle of whisky as to hand them any original-sin catechism. They are equally deadly to mind.

THEATERS IN THE EVENING.

I would make the drama a standard science, and carry dramatic expression, art, and elocution to the highest state. Historic and moral dramas would be played within the spireless church buildings in the evenings. The people of the neighborhood would alternate in being the actors, and rustic home-made plays would make young and old free from "loads of care." Trained troupes from cities would often visit every little village. Hundreds of schools of dramatic art would spring up everywhere, and lectures, concerts, recitals, oratorios, with all intellectual things, would resound throughout the land every sixth evening.

THE GREAT NEW SCIENCE, MENTALISM.

I would apply its teachings to education without delay. I would so completely upset present methods of teaching that a new type school could scarcely be recognized. I would almost change the present types of mind, and develop new kinds of human beings, like hundreds of new kinds of plants by Burbank in his marvelous California gardens. Every phase of mental culture would be based on this wonderful new all-embracing science of mind. The possibilities of this science are so great that the entire career of man can be changed by it. This science is based on differences in the minds of pupils. Born poets will not be taught the higher mathematics, and mathematicians will not be forced to wear their lives away in studies for which their minds are unfit. Two sciences are rising in the United States; they will break down all barriers and

* English Mechanic.

be taught. These are sexology and race-culture. Thus three mighty new sciences can transform the human species and make the earth a happy garden home. First, annihilate creeds. Substitute study of nature, study of mind, study of body, and produce a healthy, happy race. For it is now known that disease can be almost entirely wiped out. And students of economics are also aware that poverty may be obliterated. Changes so vast as to be beyond computation are on the way. Mediæval myths and historic horrors of a

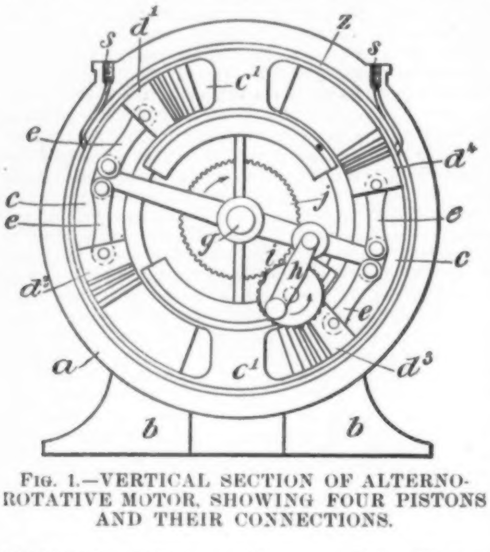


FIG. 1.—VERTICAL SECTION OF ALTERNO-ROTATIVE MOTOR, SHOWING FOUR PISTONS AND THEIR CONNECTIONS.

blood-freezing religion are about to vanish. The sun of science is rising; it is evaporating the bitter and turbid streams flowing in from a suffering past.

EDGAR L. LARKIN.

Lowe Observatory, Echo Mt., California, U. S. A.

ALTERNO-ROTATIVE GASOLINE MOTOR.

By the Paris Correspondent of SCIENTIFIC AMERICAN.

MANY attempts have been made to obtain a rotary form of explosion motor, but none of them seem to have met with success, owing to the difficulties which are inherent in this form of construction. A step toward the solution of the problem is found in the new Primat motor, which is here illustrated. This motor is not strictly of the rotary type, as the latter is understood, but is termed "alterno-rotative," seeing that the movement is produced by a set of pistons working alternately in a circular chamber, and the to-and-fro action is transformed to a rotary movement by means of a crank.

The photograph shows the interior of the motor. It is built in two similar halves, which are bolted together. The elevation and plan views show the arrangement of the working parts. In Fig. 1, c is the annular space which occupies the inside of the motor, corresponding to the cylinder of an ordinary gasoline motor. It is cut across by the two partitions, c_1, at the top and bottom. Each half of the motor contains a pair of pistons, d_1, d_2, d_3, d_4, which are connected together by the short connecting rods, e. These connecting rods are attached to a transverse power-transmitting arm, which reciprocates upon the axis of the motor and serves to combine the impulses of the four pistons. At right angles to the arm, between its center and one end, is placed a short connecting rod, h, which works on a crank pin on a pinion, i. Pinion i drives gear j, to the shaft of which is keyed the driving pulley (k^1, Fig. 2), and thus the to-and-fro movement of the pistons is transformed into a rotary movement of the pulley shaft. The latter engages with a large gear, j, which is mounted upon the main shaft of the motor. The plan view, Fig. 2, also shows the two gears, i and j, as well as the flywheel, k, on the other end of the motor shaft to that carrying the pulleys, k^1. The plan view shows, furthermore, the section of the

FIG. 4.—PHOTOGRAPH OF HALF OF MOTOR, SHOWING CYLINDERS AND VALVES.

cylinder and its water jacket, which is cast in the same piece with the cylinder. The two halves of the water jacket are thus separate, but they are connected afterward by tubing. The two halves of the motor are assembled with a special joint which is absolutely gas-tight. The second vertical section is much the same as the first, except that the pistons have been removed, and, at the upper part, is a section taken farther in the rear, which shows the valve chambers. These will also be noticed in the photograph. The two valve chambers for a pair of pistons are symmetrical at the top and bottom of the motor. At l l (Fig. 3) are the inlet valves, and the exhaust valves are at m m. The lower valve chambers have the same disposition. The spark plugs are placed at l^1 l^1. The central shaft, which is geared to revolve at half the speed of the small pinion, i, is also used to operate the four exhaust valves, m. This is carried out by a cam, g, mounted on the main shaft, which operates the tripping levers, p, of all four valves, m, during each revolution. On the same shaft are mounted the four spark contacts for the ignition. The motor uses gasoline or alcohol to form the explosive mixture in the usual way, and its operation is that of a four-cylinder, four-cycle motor.

As to the advantages which are obtained from this form of motor, one of these lies in the simple and compact form which is now secured, owing to the small space which it occupies, due to the natural and symmetrical grouping of the different parts. From a constructional standpoint, it is to be noted that the crank system is replaced by a simple crank pin and double strap, which operates the pinion. This dispenses with the use of a crank for each piston, which is generally inclosed and not easy of access. The regulation of the four cylinders is easy to carry out, seeing that all four valves are worked by the same cam. Another advantage is that the main shaft runs at half the speed of the motor itself, giving a speed reduction which is usually sought for. As to the operation of the motor, we find all the advantages of the four-cylinder form, such as division of work, ease of starting, less chance of stopping from breakage of one of the parts, and especially a good balance of the motor, which is one of the main features of the present form, owing to the movement in a vertical plane. Another advantage is

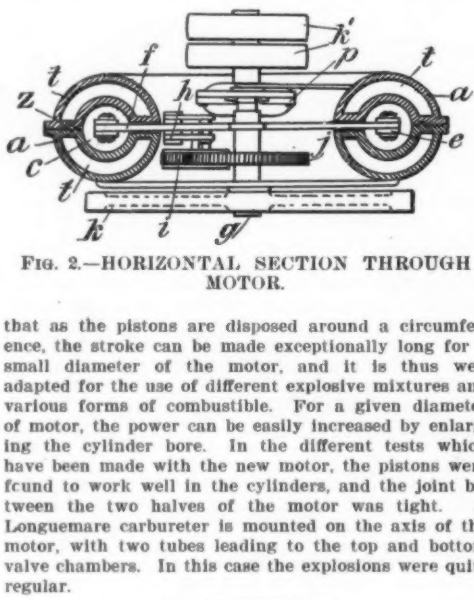


FIG. 2.—HORIZONTAL SECTION THROUGH MOTOR.

that as the pistons are disposed around a circumference, the stroke can be made exceptionally long for a small diameter of the motor, and it is thus well adapted for the use of different explosive mixtures and various forms of combustible. For a given diameter of motor, the power can be easily increased by enlarging the cylinder bore. In the different tests which have been made with the new motor, the pistons were found to work well in the cylinders, and the joint between the two halves of the motor was tight. A Longuemare carbureter is mounted on the axis of the motor, with two tubes leading to the top and bottom valve chambers. In this case the explosions were quite regular.

MORTARS AND CEMENTS.*

By BRYSSON CUNNINGHAM, B.E., Assoc.M.Inst.C.E.

MORTAR is one of the most familiar and important substances in the domain of technical science. It has a history dating back to remote ages, possibly to prehistoric times. Probably the earliest mention of it is in Sacred Writ, in connection with the building of the Tower of Babel. It must obviously, however, have been known and in existence for some time prior to the date of that renowned instance of engineering enterprise.

It is a substance commonplace enough, compounded of common materials—lime, sand and water; yet, in the eyes of the chemist, it is dignified by the wonderful metamorphoses which it undergoes throughout the various stages of its manufacture—subtle, mysterious, inexplicable almost. Furthermore, its utility is unquestionable and far-reaching. The builder, the architect, and the civil engineer would be at a loss to replace the services which it renders to them. Cathedrals and bridges, factories, dwelling houses and public buildings alike, owe their very existence to its invaluable qualities.

Technically, mortars are divided into two varieties: one in which pure lime forms the cohesive agency, and the other in which an argillo-calcareous compound is substituted for pure lime. There is a marked difference in their respective properties, and though one or two intermediate gradations containing varying proportions of both ingredients have caused some slight confusion of nomenclature, yet it may be said that, broadly speaking, the former variety is *mortar* in the ordinary acceptation of the term, while the latter is distinguishable as *cement mortar*.

By far the most important constituent of mortar is lime, a substance known to the chemist as protoxide of calcium (CaO). It occurs most commonly in nature in conjunction with a gas, carbonic acid or carbon di-

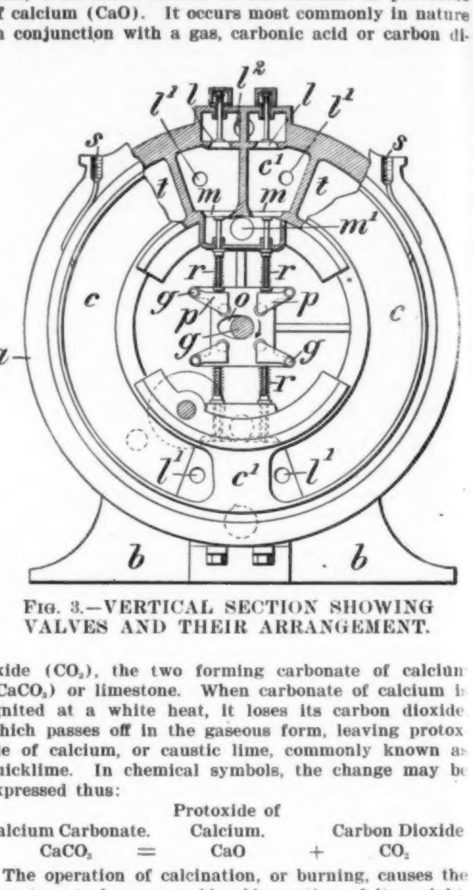


FIG. 3.—VERTICAL SECTION SHOWING VALVES AND THEIR ARRANGEMENT.

oxide (CO_2), the two forming carbonate of calcium ($CaCO_3$) or limestone. When carbonate of calcium is ignited at a white heat, it loses its carbon dioxide which passes off in the gaseous form, leaving protoxide of calcium, or caustic lime, commonly known as quicklime. In chemical symbols, the change may be expressed thus:

Calcium Carbonate.		Protoxide of Calcium.		Carbon Dioxide
$CaCO_3$	=	CaO	+	CO_2

The operation of calcination, or burning, causes the limestone to lose a considerable portion of its weight. One hundred parts of carbonate of calcium will only produce fifty-six parts of the protoxide. This is due, of course, to the loss of the gas. Becoming porous, the lime undergoes practically no diminution in volume.

Quicklime is a pure white, or very light brown substance, somewhat friable and incohesive. It possesses a great avidity for water. If this last be added freely, the lime expands and decrepitates into a fine powder, giving off great heat during the process, and ultimately developing, with the aid of sufficient water, into a paste of the consistency of soft butter. In this condition it is known as calcic hydrate or, in common parlance, slaked lime. The chemical equation is

Calcic Oxide.		Water.		Calcic Hydrate.
CaO	+	H_2O	=	CaH_2O_2

The quantity of water absorbed during the slaking process is about one-third of the volume of quicklime, some of the water being evaporated at the high temperature (150 deg. C.) which is developed. An additional and equal quantity of water is required to reduce the lime to the state of pulp in which it is used. The volume of calcic hydrate in the form of powder is some three times as great as the volume of the original carbonate from which it was produced. Fig. 1 illustrates this change of bulk graphically.

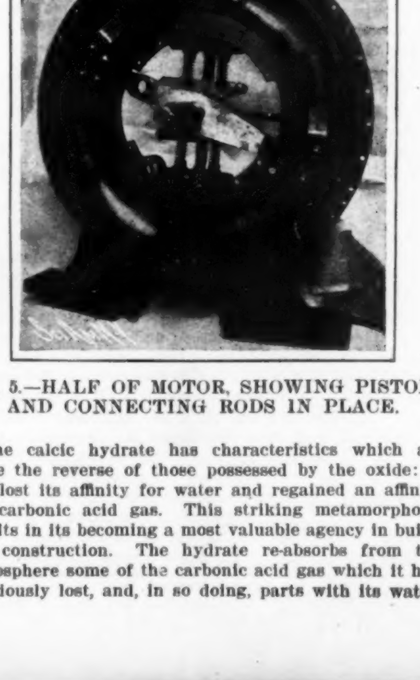


FIG. 5.—HALF OF MOTOR, SHOWING PISTONS AND CONNECTING RODS IN PLACE.

The calcic hydrate has characteristics which are quite the reverse of those possessed by the oxide: it has lost its affinity for water and regained an affinity for carbonic acid gas. This striking metamorphosis results in its becoming a most valuable agency in building construction. The hydrate re-absorbs from the atmosphere some of the carbonic acid gas which it had previously lost, and, in so doing, parts with its water.

* Technics.

This development is called *setting*, and is quite distinct from mere drying, or the evaporation of moisture. Were the action perfectly efficient, it is obvious that the carbonate would once more be created, and the cycle of operations would be complete. But this is not the case; though the process of absorption is fairly quick and well marked at first, later it falls off in intensity, and the full equivalent is never realized. In fact, pure calcic hydrate is but indifferently situated for accomplishing the ideal task. The material is not sufficiently porous to allow the carbon dioxide to penetrate into the heart of its mass, and the consequence is that a crust is formed on the outside, effectually cutting off the remainder from contact with the atmosphere. Quicklime may thus be left for a very long period without any perceptible hardening of its internal particles.

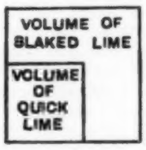


Fig. 1.—To Show the Relative Volumes of Quick and Slaked Lime.

Another characteristic of quicklime is its shrinkage or diminution in volume. Some such tendency is manifestly to be expected after its previous expansion. The contraction is very marked, taking place to the extent of 40 or 50 per cent.

These two features—imperfect setting and shrinkage—constitute grave disadvantages to the general employment of pure lime for structural operations, especially if exposed to atmospheric influence. The use for external work of mortar made from lime, though not uncommon, is greatly to be deprecated. Owing to its inherent weakness, it should be confined to internal situations, and used for decorative and ornamental purposes only.

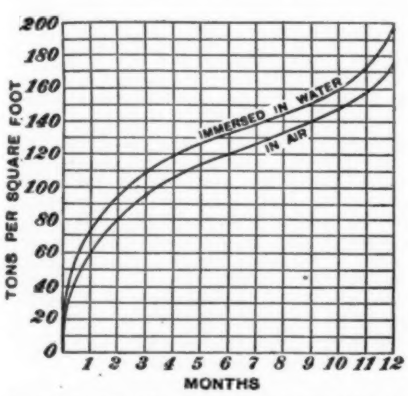


Fig. 2.—Curves Showing Resistance to Crushing of Ash-Mortar, When Allowed to Set Under Water and in Air.

To some slight extent, a corrective of the evils above mentioned is found in sand. Mixed with slaked lime in varying proportions, its porosity enables the carbonic acid gas to penetrate further into the mass; and its own unalterability reduces the proportion of shrinkage, while at the same time an economy in cost is effected. Furthermore, it improves the properties of the lime, since it is found that there is greater adhesion between the sand and the lime than there is cohesion in the lime.

Sand for mortar-making purposes should be essentially clean, sharp, and not too fine. Admixture with particles of earth, loam, clay, or other foreign matter, in any shape or form, is harmful. If the sand has been in contact with such impurities, it should be washed—that is, sifted into running water and afterward allowed to settle. Too much importance cannot be attached to cleanliness. Unless the sand be pure, the mortar will be weak and untrustworthy. On this account, mortar for building purposes is placed out of contact with the ground on a "banker," or floor of wooden deals laid temporarily, or in a tub, or upon some suitably prepared surface.

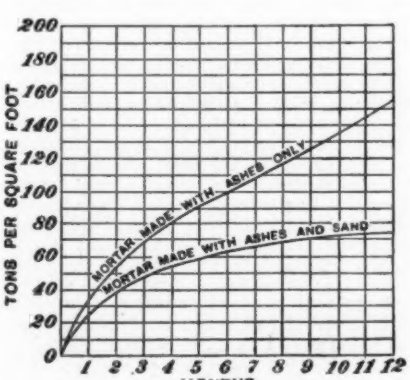


Fig. 3.—Curves Showing Resistance to Crushing of Mortar Made with Ashes, and That Made with Ashes and Sand.

Sand is obtained from three sources—from pits, river banks, and seashores—but pit sand is preferable to both seashore and river sand. The grains in the first are sharp and angular; in the other two cases, they are more or less rounded by attrition. Sea sand, moreover, has the serious drawback of being impregnated with salt; this renders it hygroscopic, and mortar made from it is always damp. In most cases there results an unsightly floury efflorescence upon the walls and other parts of a building in which it is used. Moreover, dampness retards the setting of pure slaked lime.

Whatever kind of sand be used, the incorporation of the two materials should be as thorough and intimate as possible. Every facet of the sand grains should be covered by a film of lime, and this can only be effected by prolonged manipulation. Hand mixing may suffice in certain instances where strength is not an essential matter, but the use of a mortar mill is infinitely to be preferred. The ingredients should be put into the pan in the form of slurry, and passed under the heavy revolving wheels for a period of from twenty to thirty minutes. Care must be taken neither to underdo nor overdo the process. Excessive grinding will cause too great comminution of the particles.

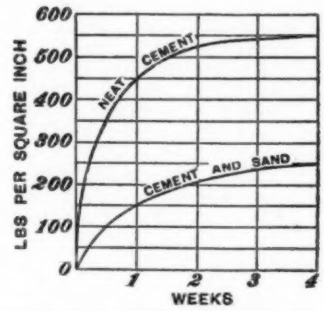


Fig. 4.—Curves Showing Tensile Strength of "Neat" Portland Cement and Cement Mixed with Sand.

Thus far we have practically only dealt with lime which is chemically pure, or "fat" lime, as it is termed by the builder. Such lime is produced from chalk, marble, and other pure carbonates of calcium. But there are many limestones in existence which yield a lime combined, in greater or less degree, with other ingredients. Sometimes these ingredients are of a negative character, such as silica in the form of sand, flinty particles, and grains of quartz. They do not, in themselves, affect or modify the slaking action, though they are impurities in the sense that they lower the strength of the lime by reducing its capacity for admixture with extraneous sand. Hence, the builder regards these limes as inferior substances, and dubs them "poor" limes. On the other hand, there are ingredients exerting a powerful constitutional influence, and the most remarkable of these is clay, which confers upon lime the valuable property of hydraulicity, or of hardening under water. Such clay-lime compounds form the class of hydraulic limes and cements.

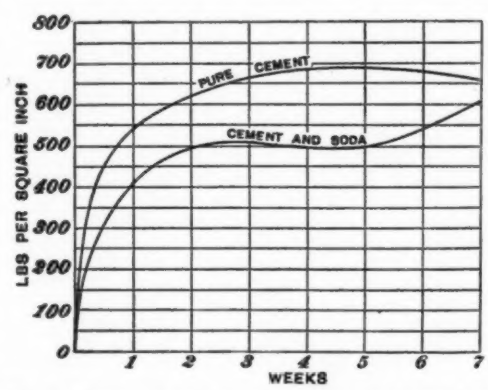


Fig. 5.—Curves Showing the Effect on the Strength of Cement Due to the Addition of Soda.

Clay is a hydrated silicate of alumina—in simpler terms, a combination of silica, alumina and water; to produce hydraulicity, it must be in chemical combination, and not merely in a state of mechanical mixture with the lime. When this condition is fulfilled, the circumstances of calcination and hydration are very materially altered. In the former operation, not only is the carbonic acid expelled and calcic oxide formed, but calcic silicates and calcic aluminates are also produced, and according to the predominance of these latter constituents, the visible effects of slaking become less and less pronounced, disappearing altogether when no free lime is left. Up to this point, the lime is classified as more or less an hydraulic lime; beyond it, the lime becomes a cement.

Much, however, depends on the intensity of calcination. Limestones containing a large proportion of iron, potash, and soda, cannot be burned at a high temperature without incurring the risk of becoming an inert mass from fusion; whereas when the proportion of these ingredients is small, the temperature may be considerably raised with safety. Now the calcic silicates are formed at a comparatively low temperature and the aluminates at a comparatively high one. If, then, a limestone is of such a nature as to be susceptible of fusion, it can only be burned at a moderate temperature; and in order to form a cement, it must contain a sufficiency of clay to provide the silica necessary to combine with all the lime: this is the basis of Roman cement. When, however, the temperature may be raised to a higher degree, a smaller proportion of clay will suffice, the excess of free lime from the first stage being absorbed in the succeeding aluminate compounds formed toward the close of the operation, and this is the constitution of Portland cement.* Roman cement nodules contain from 30 to 50 per cent of clay; Portland cement clinker from 20 to 30 per cent. In each case, the ideal cement is that which is produced from quantities so balanced that there is neither excess of lime nor excess of clay for the particular system of calcination employed.

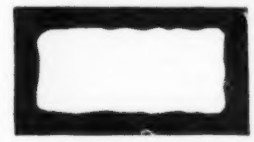


Fig. 6.—Appearance of Sound Cement.

Cements containing a large proportion of clay set with considerable rapidity, but attain no great hardness. Those in which the percentage of clay is small set much more slowly, but are noted for their enormous ultimate strength. Both classes set better under water than in air.

Having briefly reviewed the chemical and theoretical aspect of the subject, it is desirable that we should now devote some attention to the adaptation of mortars and cements to practical ends.

Sand is generally added to chalk or fat lime in the proportion of three to one by volume. Theoretically, the best proportion would be that which made the cementing agency just as strong as the cemented material. In the case of fat lime, however, the strength of the strongest mortar which can be made is insignificant in comparison with the strength of brick or stone, and it matters comparatively little what proportion of sand is used. In fact, the larger the quantity of sand, the greater the porosity of the combination, with its attendant advantages. With the proportion stated above, the resistance to crushing will be perhaps one-twentieth that of a brick. If the unit be the cubic foot, about eight gallons of water will be required to be added, and the result will be slightly over 3 cubic feet of mortar. These quantities, however, are merely approximate, and much will depend on the freshness of the lime and the coarseness of the sand.

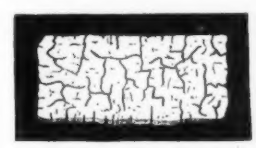


Fig. 7.—Appearance of Unsound Cement.

With hydraulic lime, a smaller proportion of sand is desirable: say two parts of sand to one of lime. About the same quantity of water will be required, but the resulting volume of mortar will be rather less.

Fig. 8.—Le Chatelier Cement-Testing Apparatus.

A very valuable substitute for sand in mortar-making is to be found in ground ashes, when these are obtainable. An excellent proportion is $3\frac{1}{2}$ parts of

* The researches of Le Chatelier have demonstrated the fact that tricalcic silicate ($3\,CaO\,SiO_2$) is the constituent to which the hardening of Portland cement is essentially due, while all the calcic aluminates (of which there are three) contribute toward rapidity of setting.

hydraulic lime to 5½ parts of ashes. Mortar made in this way gives exceedingly high results in the testing machine, as is evidenced in diagram Fig. 2. Noticeable also is the difference in the results, when the mortar is allowed to set under water and in air. In Fig. 3, the strength of the ash-mortar has not reached the value attained in Fig. 2, but it is considerably in excess of the standard set by the mortar in which one part of the ashes has been replaced by sand.

Though there are many varieties of cement on the market, the use of none is so universal as is the case with Portland cement. The manufacture of this commodity has attained extraordinary dimensions since the time when it was first discovered by Joseph Aspdin, a Leeds bricklayer, in 1824. It is a most valuable invention, and it fully deserves its world-wide reputation. As made at the present day it results from an artificial mixture of clay and lime in suitable proportions, either by means of the wet process, using chalk and clay and uniting them in water until they form a slurry of the consistency of cream, which is allowed to solidify; or by grinding limestone and shale to a fine powder and moistening: both processes being completed by burning the product in a kiln.

The average chemical composition of sound Portland cement, in round figures, is somewhat as follows:

	Per cent.
Lime	60
Silica	20
Alumina and oxide of iron	10
Magnesia, sulphur, alkalies, insoluble residue, and moisture	10

Of the last group, the insoluble residue should not exceed 1½ per cent, the magnesia 3 per cent, and the sulphur, in the form of sulphuric anhydride, 2½ per cent. Chemical analysis in the above form, however, is insufficient to determine the efficiency of a cement, for it takes no account of the degree of calcination, and it fails to distinguish between free and combined lime. This information, while known to the manufacturer, is not readily available to the consumer.

Accordingly, the engineer and the builder have to fall back upon certain physical tests, in order to assure themselves on the point. Four tests commend themselves more particularly to practical men: the first and most important of these relates to fineness of grinding. The reason for this is that the coarser particles of a badly ground cement become hydrated more gradually than the finer particles, and, consequently, they are liable to expand *in situ*, to the manifest detriment of the work. Moreover, fine cement will take a higher proportion of sand than coarse cement, and yet make a stronger mortar. Finally, the coarse particles are denser and add needlessly to the cost of carriage. Fineness is tested by means of sieves, the standard of which has been rising steadily for some time past. Several years ago, 10 per cent residue on a sieve with 1,600 meshes to the square inch, and 20 per cent residue on a 2,500-mesh sieve would not have been considered excessive. Nowadays, requirements have risen as high as a residue not exceeding 3 per cent on a 5,776-mesh sieve and 22½ per cent on a 32,400-mesh sieve. The thickness of the wire is an important point: it should be one-half the size of the opening. The following table is based on this ratio:

Number of Wires per Lineal Inch.	Number of Meshes per Square Inch.	New Standard Wire Gage.	Thickness of Wire, Inches.	Width of Opening, Inches.
50 × 50	2,500	37	0.0068	0.0132
76 × 76	5,776	41	0.0044	0.0087
100 × 100	10,000	44	0.0032	0.0067
180 × 180	32,400	47½	0.0018	0.0037
200 × 200	40,000	48	0.0016	0.0034

It is, perhaps, desirable to point out that a finely ground cement may be obtained by supplying the mills with soft underburnt "clinker," which is inferior to that heavily burnt. To prevent this, the weight, or the specific gravity, of the cement is often specified. The former, which should lie between 110 and 115 pounds per bushel, is not a very trustworthy guide, as the heavier cements are liable to overliming; moreover, cements decrease in weight as they grow old. The specific gravity should be between 3.1 and 3.15, but, even here, it is necessary to admit that the coarse particles have a higher density than the fine and more valuable "flour."

With good Portland cement, mixed neat, an average tensile strength of at least 500 pounds per square inch should be obtained at the end of twenty-eight days after mixing—one day in air and twenty-seven immersed in water. It is usual also to require a minimum average strength of 400 pounds at the end of seven days; in any case, there should be a gradual increase between the two dates, say, not less than 10 per cent. Testing is usually done in batches of six briquettes, and the figures given above will apply to the average of each batch: considerable divergency in the results of individual samples is a most unsatisfactory feature, no matter how high the average may stand. It should not fail to be noted that the preparation of the specimen briquettes exercises considerable influence on the results obtained in the testing machine. Mechanical ramming materially increases the strength; but this is generally discountenanced, and the briquette molds are understood to be filled carefully and compactly, without air holes, and also without undue pressure. Fresh water is used in mixing the paste.

In Germany, much importance is attached to a test in which the cement is mixed with standard sand, on the ground that the strength of the cement can only be properly estimated on this basis. Indeed, it has been found that of two samples of cement, one finely and the other coarsely ground, the finer cement was the weaker of the two in the neat condition, but much the stronger in combination with sand. The test has latterly been introduced into this country with gradually increasing approval. The only difficulty is to obtain a sand of rigid uniformity. The criterion usually adopted is passage through a 400-mesh sieve and retention by a 900-mesh sieve. There is a sand found in the neighborhood of Leighton Buzzard which satisfactorily answers the purpose, and it is generally specified. A briquette made with three parts of such sand to one part of cement should exhibit a tensile strength of at least 120 to 150 pounds per square inch at the end of a week, with a regular increase to 250 pounds at the end of a month. On the whole, the compressive strength of Portland cement closely approximates to ten times the tensile strength.

The third test of cement is in regard to time and duration of setting. Slowness in setting is generally indicative of strength. A quick-setting cement possibly contains an excess of clay, or some free lime, but fineness of grinding has an appreciable effect in accelerating the setting action. Setting is commonly gaged by a Vicat needle, weighing 2½ pounds, having a flat end, in some cases 1-16 inch and in others 1-20 inch square. Failure of the needle to make any perceptible impression by its own weight upon the surface of the cement marks the official close of setting, which is generally specified to lie within five hours after mixing. Various foreign substances have been utilized to influence the rate of setting. Calcium sulphate, or gypsum, added to the cement during manufacture, retards the setting action, but any excess over 2 per cent is harmful. Common soda accelerates hardening, but it weakens the cement, temporarily at any rate, as is evident from the diagram in Fig. 5. Bicarbonate of soda, on the other hand, retards the action considerably, as also do sugar, glycerine, and salt.

No unimportant test is the last one on the list. If a cement fails to pass an examination for soundness, its other qualities cannot save it from rejection. A simple pat made of cement paste, say ⅛ inch thick at the center and as thin as possible at the edges, should exhibit no sign of cracking, blowing, or expansion after twenty-four hours exposure to air or immersion in still water. Figs. 6 and 7 contrast the appearance of two pats after this test: the one sound and the other unsound. Another method is to use the Le Chatelier apparatus (Fig. 8). It consists of a small split cylinder of spring brass, having two long pointer arms. The mold is placed on a glass plate and filled with cement paste. A piece of glass is then placed on top and weighted, the whole being immersed in water for twenty-four hours. At the end of the time, the distance between the pointer ends, *a—a*, is measured and noted. The mold is replaced in cold water, which is raised to boiling point and maintained at that temperature for six hours. After being allowed to cool down, the distance between the pointer ends is again observed: any increase indicates expansion. The usual dimensions are: Diameter of cylinder, 1.18 inches; length of arm from center of cylinder to point, 6½ inches; maximum expansion permissible, 0.4 inch.

Space will not permit of any lengthy consideration of the qualities of Roman cement. It is a natural product much inferior to Portland cement, and possessing only one-third of the strength of the latter. It is most appreciated in situations where rapid setting is essential, and no great strength is required. The cement contains a large proportion of clay (30 to 45 per cent) and is burned at a low temperature, losing thereby nearly one-third of its weight. Ten bushels of unburned stone will produce about eleven bushels of cement, weighing from 70 to 75 pounds per bushel; in good cement, the higher limit should not be exceeded. Some five gallons of water per bushel are required for mixing, and the neat paste will set within ten or fifteen minutes after mixing. The average strength of sound briquettes is 100 pounds per square inch at the end of seven days, and 150 pounds per square inch at the end of a month. If mixed with sand, in a ratio which should never exceed 1½ parts of sand to 1 part of cement, the setting time is slightly prolonged and the ultimate strength greatly decreased. On account of its rapidity of action, Roman cement mortar should only be mixed in small quantities and used promptly.

There are many proprietary cements on the market: any consideration of these, however, must be deferred for the present.

METALLIC PAPER.

METALLIC paper, made by transferring, pasting, or painting a coating of metal on ordinary paper, retains, according to the Elektrizität (Berlin), a comparatively dull and dead appearance even after glazing or polishing with the burnisher or agate. Galvanized or electroplated metal paper, on the other hand, in which the metal has penetrated into the most minute pores of the paper, possesses an extraordinarily brilliant polish, fully equal to that of a piece of compact polished metal. It is much more extensively used than the kind first mentioned.

The following solutions are recommended for making "galvanized" metal paper:

For silver paper: 20 grammes argento-cyanide of potassium, 13 grammes cyanide of potassium, 980 grammes water.

For gold paper: 4 grammes auro-cyanide of potassium, 9 grammes cyanide of potassium, 900 grammes water.

For copper paper: 18 parts by weight of blue vitriol, 40 parts by weight of water, 6 parts by weight of sulphuric acid.

The solution is poured into an earthenware trough in which two plates of metal are suspended, one of which must consist of the same metal as that which is to be precipitated. If both plates are connected with the poles of a weak galvanic battery and the current is allowed to pass through the whole, a thin metallic film will be deposited on the plate which is made of the non-required metal and which must be connected with the negative pole of the battery. This film will show a remarkable polish if the plate on which it is deposited has previously been made quite smooth. The current must only be allowed to flow for a few minutes, so that only a very thin film of less than 0.01 millimeter thickness may be formed. A sheet of paper covered with paste or mucilage is then firmly pressed or rolled on to the metal. When dry, the film will be so firmly pressed into the pores of the paper that it cannot be detached; on the other hand, it can easily be removed from the metal plate on which it was previously deposited, if necessary with the aid of diluted acids.

Galvanized metal paper prepared in this manner can be treated exactly like real metal. As, moreover, all manner of ornamental figures, letters, etc., can be engraved on the plate on which the metal is deposited, this metallic paper is well adapted for advertising purposes; also for book covers and fly leaves. Still more important is its use in the manufacture of collecting brushes for dynamos. Instead of the ordinary brushes of copper or charcoal, brushes made of a compound of charcoal and metal have recently found favor. They are best made by placing thick layers of galvanized copper paper one on the top of the other and heating them to a red heat; the paper is transformed into charcoal and a compact mass is formed, consisting of alternate layers of copper and charcoal, admirably adapted for collecting brushes.

Aluminium paper, which has been recommended for use in the place of the old tinfoil, and which is much cheaper than the latter, is said to be well adapted for wrapping round food. Chemical analysis has shown that aluminium paper contains a minimum, rarely as much as 2 per cent, of iron; arsenic and other poisonous metals are never met with in the aluminium powder used in the preparation of this paper. The material on which the aluminium is applied is an artificial parchment, made by treating paper with sulphuric acid. The sheets are spread out flat and coated on one side with a thin layer of a solution of resin in alcohol or ether. Evaporation is accelerated by a current of air and the paper is then heated till the resin again becomes somewhat soft. The aluminium powder is then sprinkled over it and the whole subjected to a vigorous pressure in order that the powder may be thoroughly pressed into the paper. The metallic coating prepared in this way will remain unaffected either by the atmosphere or by fatty substances.

CHEMICAL EFFECTS OF THE X-RAYS.

AT the recent Congress of Physiotherapy, which was held at Liège, Dr. Bordier and J. Galimard, of Lyons, examine the question as to whether the X-rays have the property of bringing about chemical effects, also the action of these rays upon substances in the colloidal state. As to the chemical action of the X-rays, after some observations, they find no proof of such action. They studied the effect of the radiation upon artificial digestion and found that the latter was not retarded. It seems therefore that the rays do not act upon the inert cells. In seeking for the modifications which they might bring about in the rotatory power of certain substances in connection with polarized light, they found no change due to this cause. On the contrary, when they submitted a starch solution to the X-rays, they find that the opalescence of the solution disappears. Thus the X-rays must have an action on the substance in the colloidal state. In the discussion which followed, it was observed that the rays must have a chemical effect in some cases at least, seeing that they affect the photographic plate. In another paper, Dr. Bordier treats of the renewal of the platino-cyanide of barium screens which are used in X-ray work. It seems that this salt changes color under the influence of the rays because they remove the water vapor which is contained around the crystals of the salt. The presence of water vapor is therefore necessary to bring back the screens to the fresh state after use, and exposure to daylight alone is not sufficient. Dr. Belot, of Paris, treats of the apparatus which furnish current to the X-ray tubes, static machines, Ruhmkorff coils and transformers with closed magnetic circuit. All of these seem to give equally good results, for everything depends upon the X-rays themselves and not upon the source of current. Personal consideration alone will influence the choice of these methods. Treating the question of the tubes, he finds that only those having the osmo-regulator are to be recommended, as we can regulate them at will and thus they are capable of working for a long period, which compensates for their higher cost. As to measurements in radiology, we have two methods, the electric measurement which shows very approximately the quantity and quality of the rays which are produced, and again the measurement of Benoist's radio-chronometer and other instruments known as chrono-radiometers, but the latter instruments do not afford very

close results. Dr. Curchod, of Bale, also examines the different instruments, mentioning the spintermeter of Béclère, the X-radiometer of Sabouraud-Noisé, and the milliamperemeter of Gaiffe. These apparatus, while not yet perfect, have an importance which need not be dwelt upon, and it is probable that the continual progress in radiology will bring out a method which will allow us to provide an exactly-determined quantity of the rays for use in different therapeutical operations. Dr. Henrard, of Brussels, mentions the use of the radioscope for extracting a metallic body from the œsophagus, and claims that it is superior to the usual methods. He presents a new variety of forceps with which he seizes the foreign body under the control of the radioscope, by which the operation can be watched very easily. Dr. De Nobelle states that he also uses this method with success.

ENGINEERING NOTES.

Some of the more common impurities of waters are sediment, mud, clay, readily soluble salts, such as carbonates of lime, magnesia and iron, and sulphates of lime and magnesia, all of which produce incrustation; chloride of magnesium, acid and mine water, dissolved carbonic acid, oxygen and organic matter, all of which cause corrosion, and carbonate of soda in large amounts and organic matter from sewerage or particles in suspension, which cause priming.

Highway bridges in large cities are, at the present time, generally designed by experienced engineers, and the contracts are let in accordance with legitimate practice, the material and workmanship receiving the same careful inspection and supervision as railroad bridges. These structures, however, do not represent the general run of highway bridges throughout the country. In 1852, Squire Whipple stated, in a pamphlet published by him, entitled, "The Canal Bridges, a Specimen of the Manner of Awarding Contracts by the late Canal Board," that the highway bridges over the New York State canals were let to the highest bidders and on the poorest designs submitted. The same conditions exist to some extent at the present day.

Three propositions ought to be kept in mind by the fuel burner: *a*. The smoke from bituminous coal is a nuisance, especially in large cities. *b*. Such smoke can in the majority of cases be easily abated. *c*. Such abatement can be made a source of profit to the owner of the plant as well as to the community. There need be no difficulty in establishing these propositions by precept and by example. Objectionable black smoke is due to the presence of hydrocarbons in the fuel and is produced as follows: The hydrogen and carbon compounds in the coal are driven off as gas by the heat at a comparatively low temperature, and may escape unburned. In this condition they would not constitute smoke in the common sense of the term. If heated to a sufficiently high temperature in the presence of air they burn with a yellow flame. If the air supply is insufficient, is poorly mixed with gas, or if the temperature is lowered in any way, combustion is checked and carbon is deposited in the form of soot or carried off with the gas as smoke.

In any type of boiler it is of great importance to keep the tubes and other surfaces free of soot and scale. Otherwise, a large loss may be sustained. It is a mistake to depend entirely on the steam blower or tube cleaner, which only removes the loose soot, a scraper being necessary for occasional use to free the hard scale, which will in time accumulate on the fire surfaces. It is necessary to point out that scale, or worse still, oil on the inside of a boiler may be a source of great loss, experience having proved that even a thin film of oil will so prevent the transfer of heat that the plates or tubes will be burned in a very short time. Nothing but pure water should be used for making steam, and the practice of making the boiler do duty as a water purifier as well as a steam generator can not be too strongly condemned. If the owners of steam plants could be made to realize that a very small deposit of soot on the outside and scale on the inside means a loss of from ten to twenty per cent of the total fuel consumption, costing, perhaps, thousands of dollars per year, they would be convinced that it would be much cheaper to spend money in purifying apparatus, so that the scale or sediment will be removed before the water is fed to the boiler.

Experience shows that any of the standard types of boilers—horizontal return tubular, water-tube, or internally-fired—if they are designed with proper proportions of heating and grate surface, give about the same evaporation per pound of coal, provided they are in good condition and clean both on the fire and water surfaces. While the externally-fired boilers, either of the return tubular or water-tube type, are said to have some advantage in combustion, on account of the heat of the brick furnace, they are subject to losses which are more serious, in the way of air leakage and radiation. Tests made at the Ohio State University, by Prof. Hitchcock, show that the brick-setting of boilers continues to absorb heat up to 72 hours after being started, and that the average waste of heat in brick furnaces is about 8½ per cent. The repairs and cost of keeping up brick furnaces are considerable, and as a result of deterioration there is more or less air leakage through the brickwork going on constantly. In this respect, the internally-fired boiler has a great advantage over return tubular or water-tube boilers with brick furnaces, as it will be just as efficient after continued use as when first started.

ELECTRICAL NOTES.

The new electric cars which are the first to be built for the large Hamburg-Altona traction line and are afterward to be adopted on the Berlin lines, are now receiving their motor outfit and will soon be ready for use. The cars show several new points. They are equipped for single-phase alternating current. The overhead line will run at 6,000 volts and the cars will carry transformers for lowering the tension to 750 volts for the motors. The motors are designed to give 120 horse-power each, and the trains will run at 30 miles an hour. Arched trolleys will take the current into the car. Each of the sixteen passenger compartments will have two incandescent lamps, each one on a different circuit, for safety. Electric heaters will be used in the cars, and are placed under the seats. After the tests, it is proposed to build fifty of these six-axled cars for the Hamburg-Altona line.

In the matter of control of heat, the electric furnace stands by itself, for the rapidity of heating, duration of heating, and adjustment of the temperature are under the full and exact control of the operator. Fusions can be carried out under oxidation or reducing conditions, for the construction of the furnaces makes it very easy to operate in an atmosphere of any gas desired. Higher purity can thus be attained. The final advantage, which is really a summary of all the others, is economy of operation. The economy of the electric furnace as compared with that of other furnaces requires the balancing of electrical energy against energy obtained from the combustion of fuel, cost of installation and maintenance of the equipment, amount of labor, value of product, danger to operatives. A careful weighing of these factors in a considerable number of metallurgical and chemical operations on an industrial scale has shown the resultant advantage to lie with the electric furnace.

Although there have always been a few patient workers in the field of medical electricity, it is nevertheless the case that among the rank and file of the profession the interest excited by electrical methods of treatment has been slight. To those who judged merely by results the field seemed to be a barren one and so long as electricity was used in medicine mainly for the relief of states of debility, for the treatment of chronic paralytic affections and for old rheumatic cases, one could understand this attitude. The results of electrical treatments in these morbid conditions were of the same order of merit as those afforded by change of air, by sea-bathing, or by shampooing and gymnastic exercises, and as they entailed more trouble for their administration they failed to attract the busy practitioner. Electrotherapeutics could not thrive so long as it served mainly as a useful adjunct or accessory to other modes of treatment, but it has now made many forward strides and is becoming able to take a leading part in the treatment of many morbid states.

A novelty in the way of an insulated electric wire has recently been brought out by the well-known German firm Allgemeine Gesellschaft, of Berlin, and the new wire is said to have been already put upon the market. It is known as "acetate" wire and is designed to replace the silk or cotton covering of wires which are used for electro-magnets, especially in the case of small currents. It has an advantage in that the insulating layer takes up less space than usual, and a given coil will therefore contain more wire. At the same time the electrical and mechanical properties of the new insulating material are claimed to be superior. At present we are obliged to give a double or triple covering of silk or cotton and even then it must often have a layer of varnish applied to it so as to diminish the hygrometric properties of the covering, and this also adds somewhat to the diameter. The new wire consists of a continuous covering which is formed essentially of a substance remarkable for its insulating properties, the tetra-acetic cellulose. It is applied in numerous coats on the copper wire by a special machine. This coating is both flexible and durable, of a great elasticity and solidity, and although it has only a thickness of 0.0008 inch it seems to have mechanical qualities which make it superior. It is moisture-proof and is not affected by temperatures up to 150 deg. C. The insulation resistance is very high and a thickness of 0.0008 inch is only broken down by a tension of 1,500 volts. Such a covering would seem to form a notable progress in the way of insulated wires. The company are making wires at present ranging from 0.0028 to 0.006 inch diameter.

The first application of electric traction on the Prussian state railroads is to be made on the Blankensee-Ohlsdorf line in the suburbs of Hamburg. This line is to be fitted out after the system which the Union Electric Company adopted on the line from Niederschöneweide to Spindlersfeld, using the single-phase alternating current. On the Hamburg line, the distance is 18 miles, with the stations spaced about a mile apart. Here the traffic is quite variable during the day, and it varies from 1,000 passengers per hour down to 100 passengers. To provide for the variations the system is to use trains which are composed of from one to fours cars of 70 places each. The trains are to run at five-minute intervals upon the suburban portion and at 10 and 20 minute spaces in the outer parts of the line, during the week. An electric station is to be erected near Altona. It will contain 12 boilers and the dynamo hall will have five Brown-Boveri steam turbine groups, each giving about 2,000 horse-power and operating at 1,500 revolutions per minute. It will also have two smaller steam turbines of 800 horse-power for the lighting current. Each of the large turbines will be coupled to a double-pole alternator of the Siemens-Schuckert pattern, which will furnish current at 6,600 volts. From Blankensee to Hasselbrook, the line will be supplied with current at a tension of 6,600 volts. For the remainder of the line, the station will give a raised tension of 20,000 volts, and this will be again lowered on the spot. An overhead trolley line, with the usual rail return, will be used here. Six-axle cars will form the trains on the Hamburg line; however, each car is in reality made up of two shorter cars of three axles each, and the cars are joined together by a short coupling system. Each of the two parts will rest upon a movable truck. One of the latter will carry two motors of the Winter-Lichberg (German) make, having a capacity of 125 horse-power. The second truck will have a single motor of the same power. Each of the cars will weigh about eighty tons when in running order. The line is expected to be ready for operation in the latter part of next year.

TRADE NOTES AND FORMULÆ.

To Render Cloth Waterproof.—Dissolve in a receptacle, preferably of copper, over a bright coal fire, 1 liter of pure linseed oil, 1 liter of petroleum, ½ liter of oil turpentine, and 125 grammes of yellow wax, the last named in small bits. As there is danger of fire, boiling of this mass should be avoided. With this hot solution removed from the fire of course the felt material is impregnated, next it is hung up in a warm, dry room or spread out, but in such a manner that the uniform temperature can act upon all parts.—Werkmeister Zeitung.

Cleaning Polished Articles of Copper, Bronze, Etc.—Objects of polished copper, bronze, brass, and other alloys of copper tarnish through water and it is sometimes necessary to give them again their bright appearance. To obtain good results it is by no means indifferent what method is pursued. Experience has taught us that the best way consists in pickling the article in an acid bath, to wash them next in a neutral bath, to dry them, and subsequently to rub them with a polishing powder. Such is the general formula; the processes indicated below are but variants adapted to divers cases and recommended by disinterested experimenters.

Polished Copper.—Make a mixture of powdered charcoal, very fine, 4 parts; spirit of wine, 3 parts, and essence of turpentine, 2 parts; to this add water in which one-third of its weight of sorrel salt or oxalic acid has been stirred, and rub the objects with this mixture.

Bronze Articles.—Boil the objects in soap lye, wash in plenty of water, and dry in sawdust.

Brass Articles.—It would not suffice to pickle brass objects, the brilliancy thus produced would not be durable. To attain a good polish, the surfaces have to be rubbed with very fine tripoli mixed with olive oil; next rinse with soap water and wipe dry with fine linen.

Gilt Frames.—Mix and beat the whites of three eggs with one-third, by weight, of javelle water, and apply to the gilt work, which will be quickly restored to newness.

Highly Oxidized Bronzes.—First dip in strong soda lye, then in a bath containing 1 part of sulphuric acid to 12 parts of water. Rinse in clean water, and next in water containing a little ammonia. Dry and rub with a polishing powder or paste.

Delicate Objects.—Rub them with a sponge charged with a mixture of 28 parts of alcohol, 14 of water, and 4 of lavender oil.—Revue de l'Automobile.

Production of Small Statues by Means of the Amalgam of Lipowitz Metal.—This amalgam is prepared as follows: Melt in a dish cadmium, 3 parts, by weight; tin, 4 parts; bismuth, 15 parts, and lead, 8 parts, adding to the alloy, while still in fusion, 2 parts of quicksilver previously heated to about 100 deg. C. The amalgamation proceeds easily and smoothly. The liquid mass in the dish, which should be taken from the fire immediately upon the introduction of the mercury, is stirred until the contents solidify. While Lipowitz alloy softens at 60 deg. C. and fuses perfectly at 70 deg. C., the amalgam has a still lower fusing point, which lies around 62 deg. C.

This amalgam is excellently adapted for the production of impressions of various objects of nature, direct impressions of leaves and other delicate parts of plants having been made with its aid, which in point of sharpness are equal to the best plaster casts and are possessed of a very pleasing appearance, the amalgam having a silver-white color and a lovely gloss. It is perfectly constant to influences of the air. This amalgam has also been used with good success for the making of small statuettes and busts, which are hollow and can be readily gilt or bronzed by electro-deposition. The production of small statues is successfully carried out by making a hollow gypsum mold of the articles to be cast and heating the mold evenly to about 60 deg. C.; a corresponding quantity of the molten amalgam is then poured in and the mold moved rapidly to and fro, so that the alloy is thrown against the sides all over. The shaking should be continued until it is certain that the amalgam has solidified. When the mold has cooled off it is taken apart and the seams taken off by means of a sharp knife. If the operation is carried on correctly, a chasing of the cast mass becomes unnecessary, since the alloy fills out the finest depressions of the mold with the greatest sharpness.—Der Metallarbeiter.

SCIENCE NOTES.

Of recent discoveries, the one which appears to carry the greatest weight is that of Novy and McNeal. They have been the first to obtain pure cultures of Protozoa, maintaining typanosomes of different species alive *in vitro* for many generations. There is no telling whither the methods they have given us may lead; they directly stimulated Leonard Rogers to experiments wherein he succeeded, by an ingenious method of his own, in cultivating another protozoon, the Leishmania, obtained from cases of kala-azar.

Mascart reported at the last session of the Paris Academy of Natural Philosophy on the action or influence of the solar eclipse upon the magnetic needle based upon researches conducted by Moreaux. He placed his instruments in a well twenty meters below the surface of the earth where no temperature changes had to be feared and observed that during the eclipse the needle deviated four minutes. He was also able to ascertain through measurements taken at different places above the earth that the temperature decreased 1½ deg. C. during the eclipse.

Geography is one of the most ancient subjects studied with the view of co-ordinating facts. A desire for exact knowledge of, first, the bearings and distances of one place from another for the purposes of intercommunication must have arisen as soon as men became collected into groups whose growing civilization and needs required travel to obtain what could not be obtained in the community. This was the earliest form of geography, and it is an aspect which still remains, and to some is, in the modern shape of maps, the principal, if not the sole, end of geography.

According to the Umschau, the weight of the brain of the largest land animal is three times that of man. But while the human brain weighs one-fortieth of his total weight, the elephant's brain amounts to only one-five-hundredth of the weight of his giant body. These numerical ratios are of mnemotechnical interest, since the figures 3, 4, 5, and the divisor of 1, 10, and 100 can be readily retained by the memory. As regards relative brain weights, man is excelled only by a few birds, but this absolute superiority in the size of the brain is only an apparent one, owing to the specific lightness of the body of birds.

The following extract on the importance of moisture in the life of the plant is taken from Johnson's "How Crops Feed": "Let us suppose dew or rain to have saturated the ground with moisture for some depth. On the recurrence of a dry atmosphere with sunshine and wind, the surface of the soil rapidly dries; but as each particle of water escapes (by evaporation) into the atmosphere, its place is supplied (by capillarity) from the stores below. The ascending water brings along with it the soluble matters of the soil, and thus the roots of the plants are situated in a stream of their appropriate food. The movement proceeds in this way so long as the surface is drier than the deeper soil. When, by rain or otherwise, the surface is saturated there is no longer any ascent of water; on the contrary, the water, by its own weight, penetrates the soil, and if the underlying ground be not saturated with moisture (as can happen where the subterranean fountains yield a meager supply) then capillarity will aid gravity in its downward distribution. . . . It is easy to see how, in good soil, capillarity thus acts in keeping the roots of plants constantly immersed in a stream of water or moisture that is now ascending, now descending, but never at rest, and how the food of the plant is thus made to circulate around the organs fitted for absorbing it. The same causes that maintain this perpetual supply of water and food for the plant are also efficacious in constantly preparing new supplies of food. . . . The more extensive and rapid the circulation of water in the soil, the more matters will be rendered soluble in a given time; and, other things being equal, the less will the soil be dependent upon manures to keep up its fertility."

We have now about a hundred million stars in sight, and astronomers have been surprised that a greater number of the more remote ones are not to be seen. The actual number of stars in our universe is much smaller than had been supposed, and instead of there being an infinite number in an infinite space the present outlook is that there is a boundary to the visible universe; but this remains to be determined, and this problem is engaging attention in several of the great observatories. We all want to know what kind of a universe we live in and the series of events that take place in it. In older times there were supposed to be but seven members of the solar system. The nineteenth century discovered more than five hundred. Eros was discovered only six or eight years ago, while additional moons to both Jupiter and Saturn were seen for the first time within ten years. It is not probable that all have been discovered. Search is yet being made for other planets. Though limited, one can get some idea of the magnitude of the universe when it appears that some of the remote stars are so far away as to require something like a million years for their light to reach us, though light travels at the rate of 186,000 miles a second—a distance so great that it would take trillions of years to reach them at the rate that we now are moving in space, namely about 400 millions of miles a year. Space seems illimitable, time is long, and if matter be indestructible, yet the solar system as we know it will have gone through all its phases of growth, maturity, old age, and death, long enough before the general aspect of the heavens will have been greatly changed from what it is to-day. This is astronomical work of importance awaiting research.

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